

# THE ASH APOCALYPSE IS COMING!

## Why a volcano disaster is 16,000 years overdue

# World of Knowledge

Discover Something New



## LEADERS WHO CHANGED HISTORY

THE STORIES BEHIND THE LEGENDS

ISSUE 31 OCTOBER 2015  
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AUSTRALIA

SECRET AREAS  
UNCOVERED

## INSIDE THE WORLD'S MOST FORBIDDEN PLACES

++ Religious archives ++  
Government vaults ++ Doomsday bunkers

**REAL-LIFE CRIME**  
The cruise-ship murders baffling detectives

**WONDERS OF SCIENCE**  
Why this man will perform the first HEAD transplant

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PLUS: **DISCOVER** the bird as clever as a 7-year-old! / **LEARN** how to view the start of the universe!





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Win an exciting 14-day holiday for two to the Kimberley with APT at this year's Australian Geographic Society Gala Awards in Sydney on 28 October 2015.

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This celebration of adventure and conservation is the Australian Geographic Society's major annual fundraising event and there are other great prizes to be won in the raffle and silent auction. Proceeds from the night go towards supporting the organisation's sponsorship program, which funds conservation, community, science and adventure in Australia.

This year's gala dinner will be hosted by Catriona Rowntree. You have to be in it to win it, so book now and secure your place at this night of nights.

Visit [www.australiangeographic.com.au/awards2015](http://www.australiangeographic.com.au/awards2015) now to purchase tickets, but hurry – places are limited and it's always a sell-out occasion.

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GALA  
AWARDS



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# World of Knowledge

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It turns out crows are seriously clever!  
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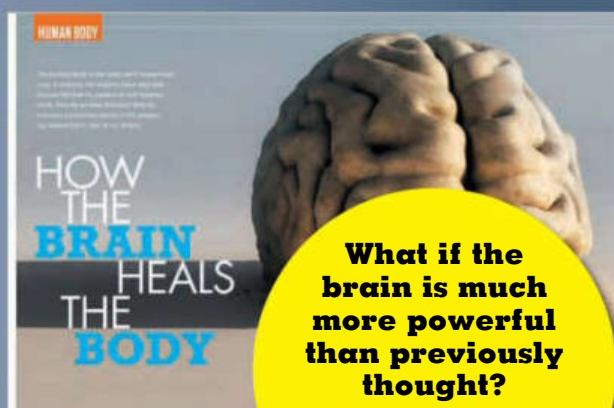
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## WELCOME FROM THE EDITOR



The hardest part of this job is, every month, condensing the amazing world we inhabit into just 100 pages. "First-world problem!" I hear you cry, and you'd be right. But even trickier than that conundrum is then condensing what we've already condensed. Six visionary leaders who changed the world? Where to start. Editing hundreds of incredible photos of exploding volcanoes? I feel a lie-down coming on.

And it's not just info-overloaded editors. One of our freelance writers emailed during the making of this issue, exasperated by the word constraint imposed on him by yours truly for the Forbidden Places cover story. "That North Korea section needs a whole book!" implored our scribe. And he was only on the first mini-story in the piece. There were six more to be written.

Luckily he found a cure for his own FWP, turning out an intriguing probe into the secrets lurking behind the planet's most guarded sites. My personal favourite is Norway's Svalbard Global Seed Vault, an underground installation deep in the Arctic Circle, designed as an agricultural fail-safe in the event of some apocalyptic disaster. More than 4,000 different plant species and vital crops are kept at the facility, ready to be used if civilisation needs to be rebooted. Picking 4,000? Now that's what I call an edit.

Vince Jackson, Editor

**THE ASH APOCALYPSE IS COMING!**  
Why a volcano disaster is 16,000 years overdue

# World of Knowledge

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**SECRET AREAS UNCOVERED**

**AUSTRALIA**

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# EXPERTS IN THIS ISSUE



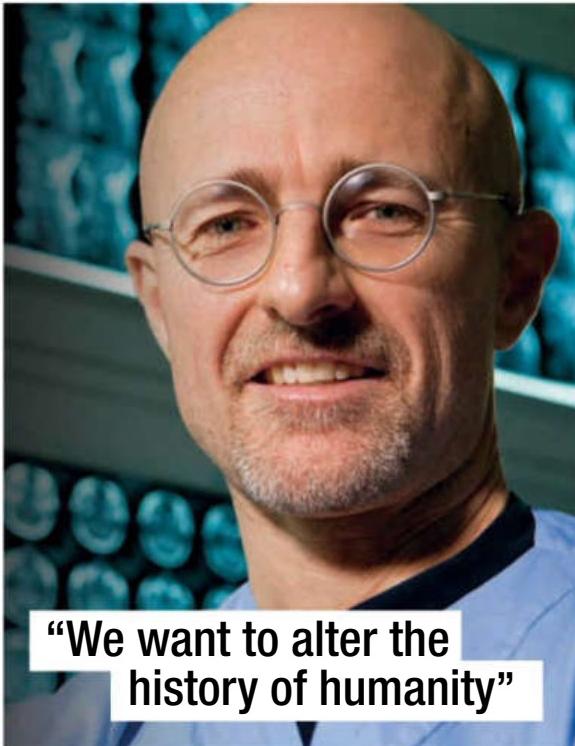
Crows are far more intelligent than most people assume



John Marzluff

**THE MAN WHO SPEAKS TO CROWS**

Even after researching corvids for many years, the American ornithologist continues to be amazed by them. Discover why on page 68.



"We want to alter the history of humanity"

Sergio Canavero

**DR FRANKENSTEIN**

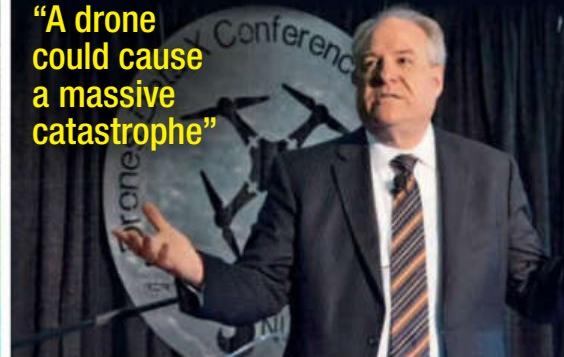
Sergio tells *World of Knowledge* how he plans to transplant the head of one person onto the body of another. Find out why he's the most controversial doctor in the world right now on page 34.

Jim Williams

**THE AIRSPACE CONTROLLER**

Jim works for the Unmanned Aircraft Systems Office at the US Federal Aviation Administration (FAA). Find out why he's sounding the alarm on page 60.

"A drone could cause a massive catastrophe"



Christopher Shays

**CRUISE CRIME CAMPAIGNER**

Christopher is a US politician. He argues that "jurisdictional and bureaucratic tangles" can prevent the investigation of crimes at sea. All the facts are on page 38.

"An investigation can be difficult when the crime scene literally floats away"



"We're looking for the first light in the universe!"

Amber Straughn

**THE EXPLORER**

Amber is a deputy project scientist on the James Webb Telescope project. Using this high-tech device, the passionate pilot hopes to discover new planets, galaxies and star systems – as well as seeing the birth of our universe. Read more on page 82.

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AMAZING PHOTO

# THE BIGGEST BUILDING SITE IN THE WORLD

For 101 years, the Panama Canal between the Atlantic and the Pacific has been considered the global economy's most important lifeline.

Now an unmatched feat of engineering will help it keep that title



## 34 YEARS

is how long the 56,000 workers spent building the Panama Canal [above] before it was first opened in 1914. Since then more than a million ships have passed through the canal in Central America. Eight years ago the expansion of the 80-km-long, 12-metre-deep canal finally began. The excavating work and new mega-locks will cost \$5 billion to complete and should be open for business by the end of next year.

## 15 MASSIVE CONTAINER SHIPS

will pass through the new locks every day. Every ship will need over 200 million litres of water to be pumped into each of the three 427-metre-long chambers.

**S**wat runs down Jorge Luis Quijano's forehead. But that's probably got nothing to do with Panama's humid jungle air or the sticky 30-degree temperature. Quijano is the construction manager of the biggest building site in the world: the expansion of the Panama Canal. He's overseeing a haulage truck slowly

manoeuvring a 3,000-ton steel 'wall' into the new floodgate – the first of 16 gates that will be placed in the new canal, which is scheduled to open by the end of next year. Like gigantic doors, every month they will ferry thousands of container ships through the most important arteries of the world economy. After six hours Quijano can catch his

breath, as the first floodgate has been expertly slotted into place. Fifteen still need to be installed before a new era of ship-faring can begin.

#### HOW MUCH DOES A 16,000-KILOMETRE DETOUR COST?

The Panama Canal first opened its floodgates 101 years ago. Since then >



more than a million ships have passed through the canal. The problem: over the years container ships have grown in size. The old canal is only fit for Panamax-class ships – those with a maximum length of 305 metres and width of 33.5 metres. For that reason many larger container ships have to take a 16,000-kilometre detour around Cape Horn in South America. And that doesn't just add two weeks to the journey, it also costs \$4 million in extra fuel. Once the \$5 billion expansion of the Panama Canal is completed, this detour will be history.

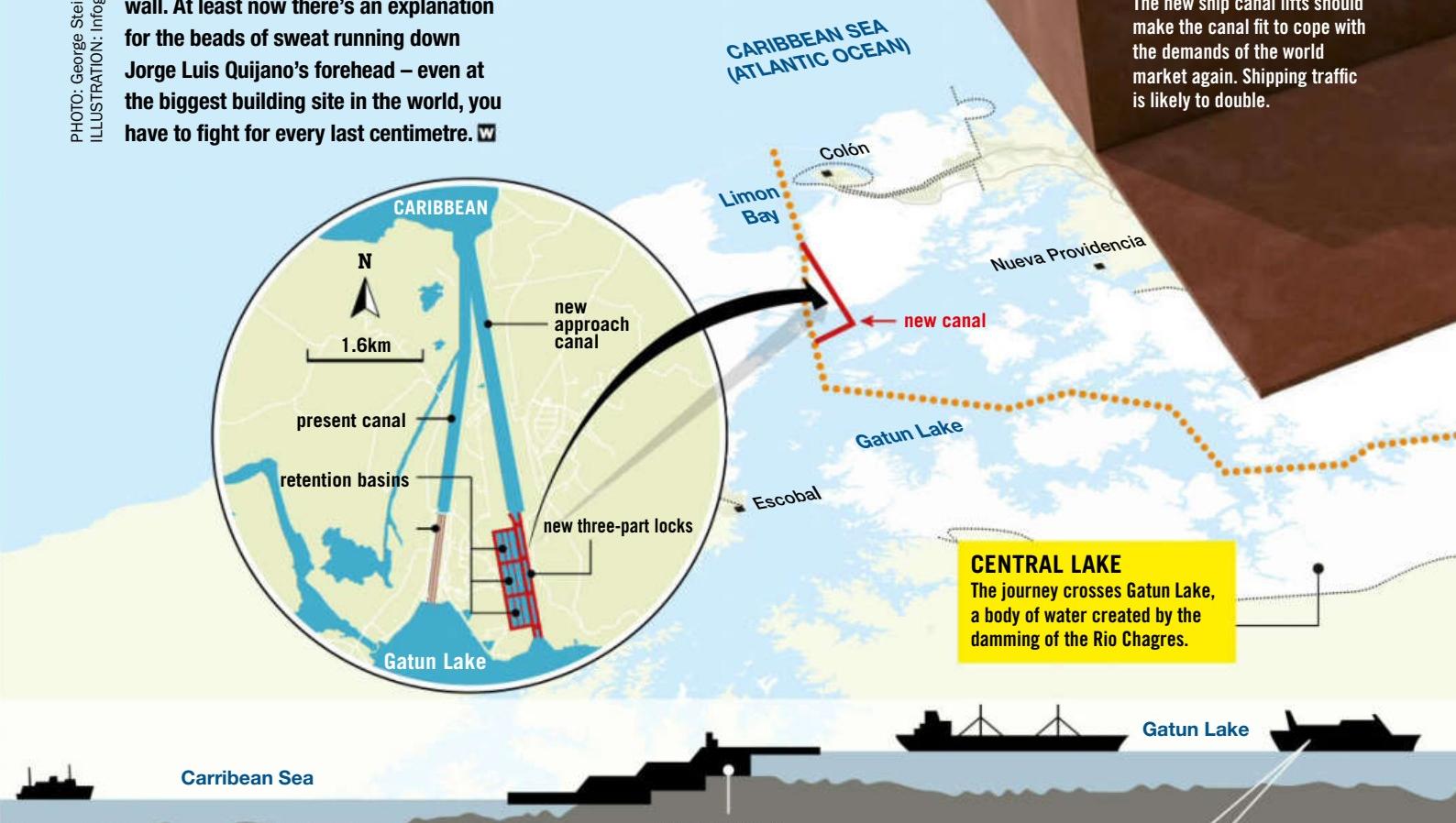
For the past eight years 32,000 workers have been dredging the area. In the future, freighters with a transport capacity of 13,000 containers will be able to pass through the canal. But the giants of the oceans still won't have much extra room for manoeuvre, even in the widened Panama Canal. In the new lock, where the first floodgate is being installed, there's only 60 centimetres of wiggle room between the boat and the concrete wall. At least now there's an explanation for the beads of sweat running down Jorge Luis Quijano's forehead – even at the biggest building site in the world, you have to fight for every last centimetre. □

PHOTO: George Steinmetz  
ILLUSTRATION: Infografika/Focus-Magazin



### THE SUPER HIGHWAY

The new ship canal lifts should make the canal fit to cope with the demands of the world market again. Shipping traffic is likely to double.



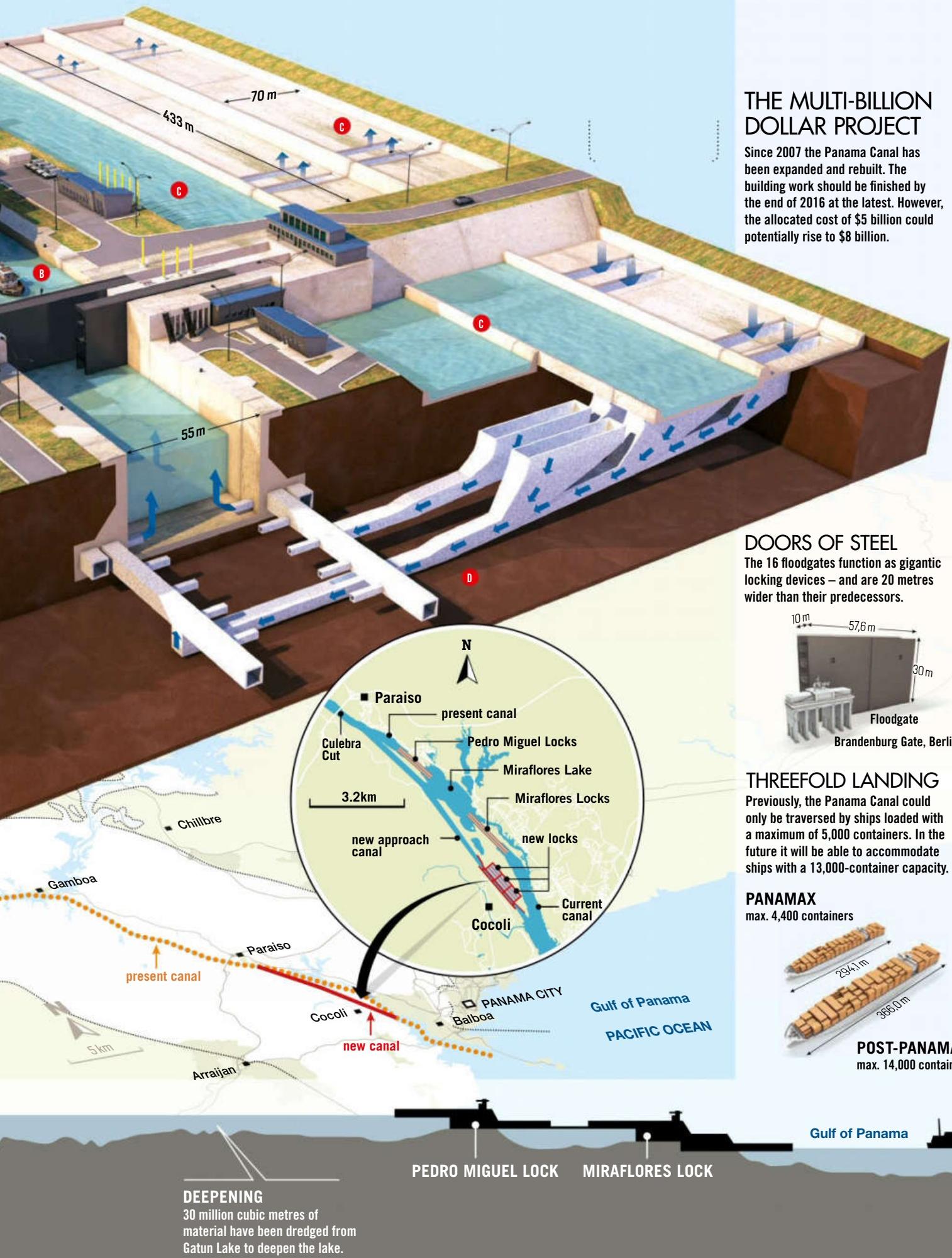
**FROM THE ATLANTIC TO THE PACIFIC**  
Gatun Lake lies 26 metres above sea level. The new three-part lock system enables the container ships to overcome this height difference.

### EIGHT TO TEN HOURS

That's how long the average passage lasts, though it can take up to 24 hours. Without the canal, however, the journey around South America would take at least three weeks.

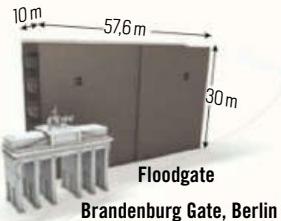
## THE MULTI-BILLION DOLLAR PROJECT

Since 2007 the Panama Canal has been expanded and rebuilt. The building work should be finished by the end of 2016 at the latest. However, the allocated cost of \$5 billion could potentially rise to \$8 billion.



## DOORS OF STEEL

The 16 floodgates function as gigantic locking devices – and are 20 metres wider than their predecessors.

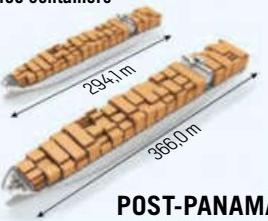


## THREEFOLD LANDING

Previously, the Panama Canal could only be traversed by ships loaded with a maximum of 5,000 containers. In the future it will be able to accommodate ships with a 13,000-container capacity.

### PANAMAX

max. 4,400 containers



POST-PANAMAX  
max. 14,000 containers

Gulf of Panama



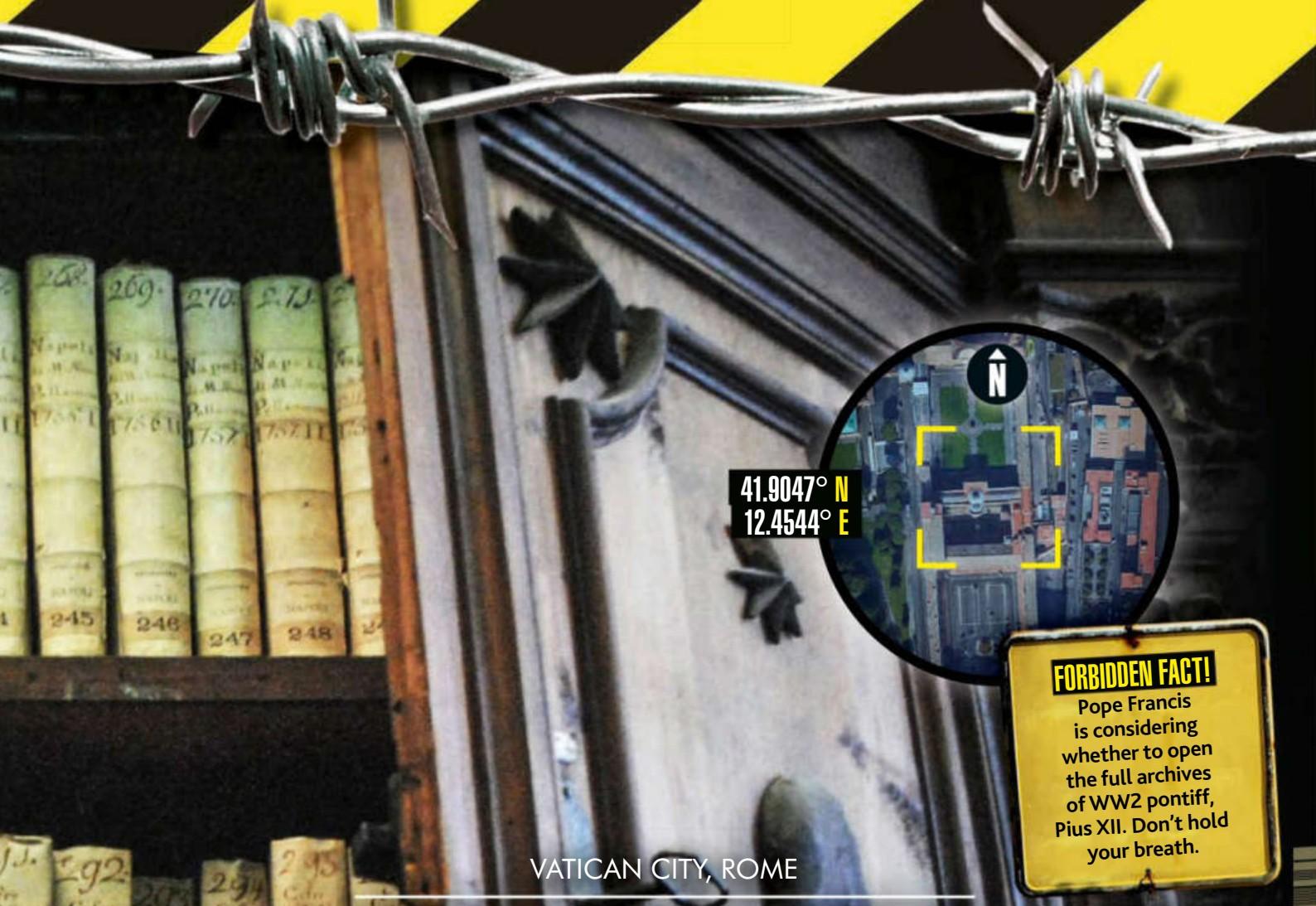
### DEEPENING

30 million cubic metres of material have been dredged from Gatun Lake to deepen the lake.

WORLD EVENTS

# INSIDE THE WORLD'S MOST FORBIDDEN PLACES

Access to the general public is strictly off-limits.  
And often, the exact nature of their contents is  
on a need-to-know basis. Here the planet's  
most protected sites reveal their secrets



## VATICAN CITY, ROME

# VATICAN SECRET ARCHIVES

# THE POPE'S CLANDESTINE UNDERGROUND LIBRARY

**T**hey sound like the setting for a Dan Brown novel, but the Vatican would like you to know that the 'Secret' in their title doesn't carry its modern meaning. A more accurate translation of their latin title – Archivum Secretum Apostolicum Vaticanum – would be Private Archives.

This vast library of historic documents, held in the luxuriant grounds of Vatican City, is estimated to be stored on some 84 kilometres of shelving and to contain more than 35,000 volumes. The Archives, founded in 1612, are the property of whoever is the Pope at any given time, and house some truly remarkable artefacts, dating back as

far as the end of the eighth century – including King Henry VIII's historic, and failed, request for a marriage annulment, as well as letters from the great artist Michelangelo, who painted the Sistine Chapel nearby.

Documents relating to the persecution of Galileo Galilei for the heresy of suggesting the Earth was not the centre of the universe are also held here, while conspiracy theorists believe the Archives also contain evidence of extraterrestrial life and even ancient texts that disprove the existence of Jesus, as well as contemporary portraits of him (i.e. painted by people who actually saw him, as opposed to the earliest pictures we have now, which

date to the late second century).

Further confounding the ‘secret’ tag is that, since 1881, qualified scholars have, occasionally, been allowed to access the Archives (students, journalists and, presumably, popular novelists are banned), although they are not allowed to see any materials dated after 1939. If you can construct a sentence with the words ‘Nazis, conspiring and Catholic Church’, you might be able to postulate a theory as to why.

In 2012, the Vatican celebrated the Archive's 400th anniversary by putting a relatively tiny collection of 100 items on show to the public at the Capitoline Museums in Rome.



PYONGYANG, NORTH KOREA

# ROOM 39

## KIM JONG-UN'S CRIMINAL BANK

**N**orth Korea gives new meaning to the term ‘two-speed economy’. Satellite photos show most of the country living without electricity at night, and citizens are asked to eat two meals a day. Meanwhile, the ruling classes, led by Kim Jong-un [below], enjoy cognac, fast cars and caviar.

In a country that is theoretically broke – with a trade deficit of over US\$10 billion – this separate ‘palace economy’ is reportedly paid for by a vast, global criminal organisation, centred in what’s known as Room 39 in Pyongyang, not far from Kim’s luxury villa.

The clandestine Room 39 was set up by Kim Il-sung (Jong-un’s

grandfather) in the late-1970s, and now reportedly makes up to US\$2 billion a year by forging ‘supernotes’ of US currency, producing and trafficking drugs like heroin and crystal meth, selling fake cigarettes and pharmaceuticals, and running insurance scams.

Criminal activity, on a huge scale, is an integral part of North Korea’s economy. “It not only pays,” says political expert, David Asher, “it plays to their strategy of undermining Western interests.” He adds, “In one sense, Room 39 is like an investment bank. It provides the money for the stuff Kim needs.”

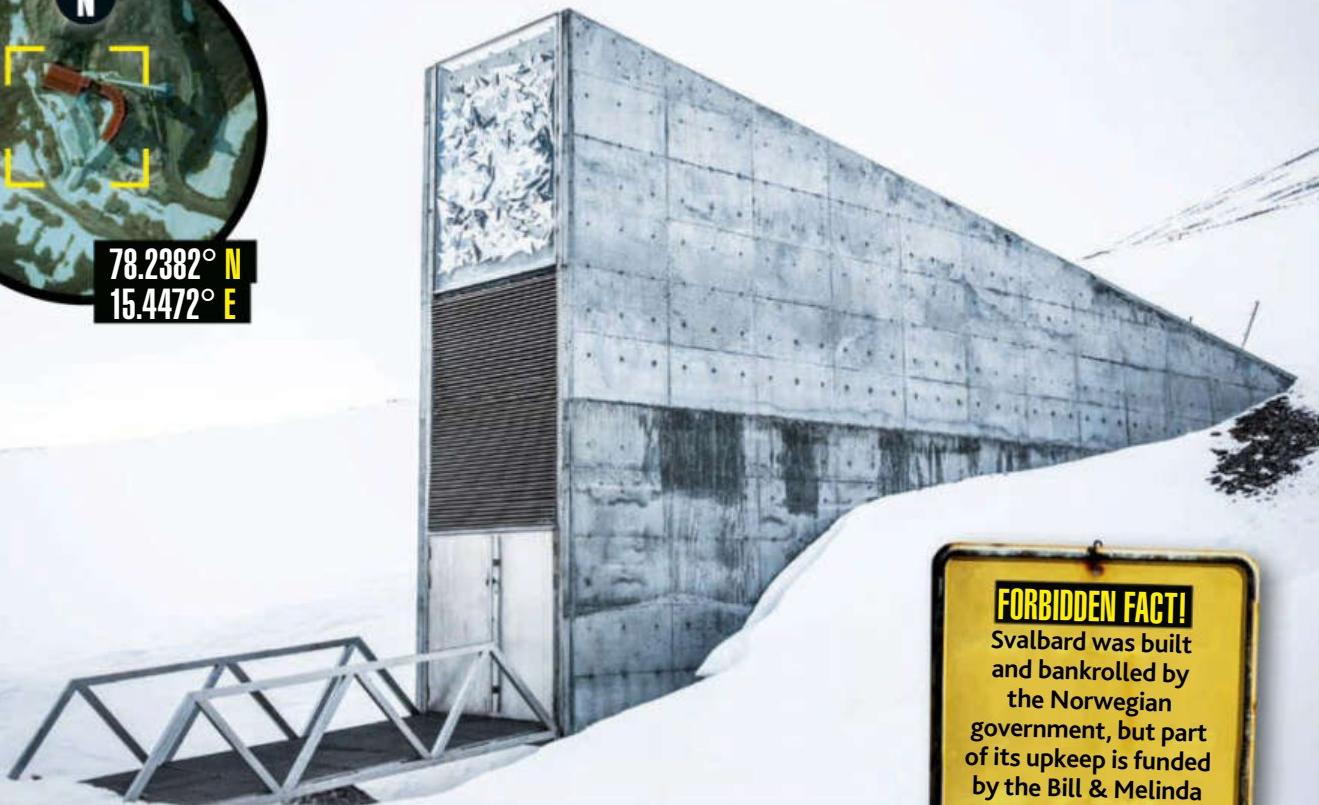
Room 39’s elite staff of about 130 people plan and supervise foreign criminal operations, which are then

carried out by local crooks, as well as overseeing the factories that produce forged bank notes, drugs and other saleable contraband.

The forged supernotes are said to be of incredibly high quality. In 2007, North Korea reputedly bought enough of the special Fourdrinier paper needed to print them to produce US\$2 billion worth.

The US Treasury recognised the existence of Room 39 in 2010, describing it as a secretive branch of the North Korean government “engaging in illicit economic activities and managing slush funds and generating revenues for the leadership”, announcing sanctions against anyone connected with its enterprises.





NORWAY, ARCTIC CIRCLE

## SVALBARD GLOBAL SEED VAULT

WHERE HUMAN CIVILISATION CAN BE REGROWN

**I**t looks like it might be jutting out of the Wall in the frozen north of the *Game of Thrones* universe, a shard of light-bouncing steel with what looks like jewellery on the roof. But it is, in fact, the rather impressive entry lobby for the Svalbard Global Seed Vault in Norway.

Designed for a “virtually infinite lifetime”, the building is buried 130 metres into the frozen ground of Platåfjellet (Mount Plateau), and is also 130 metres above sea level, so as to outlast the very worst of climate change. The eye-catching lobby has an artwork on its roof, which uses reflective stainless-steel triangles, mirrors and prisms to reflect sunlight and snow with dizzying effect.

This otherworldly entrance, almost 1,300 kilometres north of the Arctic Circle, gives no hint of just how vast the subterranean, sub-zero network of vaults that lies beneath is.

A corrugated steel pipe runs from the lobby some 100 metres into the base of the mountain, to the three giant, dry and freezing rock vaults where copies of virtually all the seeds in the world are safely stored.

The total area of the facility – which can hold up to five million seeds – is 1,000 square metres, and it’s not the kind of place that would be fun to work, with refrigeration equipment keeping the vaults at a brisk minus 18 degrees Celsius.

Officially opened in 2008, the Svalbard Global Seed Vault now holds the seeds of more than 4,000 different species of plants, including vital crops like rice, wheat and beans.

All the samples are essentially fail-safes, as they are duplicates of seeds held in other national and international gene banks around the world. And they remain the property of the gene banks that deposit them in the super-secure Svalbard facility.

These frozen, hidden vaults keep their copies so that valuable plant varieties can be recreated if necessary after any kind of local or international crises (or apocalyptic disaster) causes them to be lost.

VIRGINIA, USA

# MOUNT WEATHER

## OBAMA'S DOOMSDAY BUNKER

**A**mid the chaos and carnage that was 9/11, one of the less-discussed strange events was a traffic jam of limousines with government plates leaving Washington DC and heading 100 kilometres down Virginia State Route 60. The top Congressional leaders had already been helicoptered to the Mount Weather Emergency Operations Center, command post for the Federal Emergency Management Agency (FEMA).

On that same day, John Staelin, a member of the Clarke County Board of Supervisors, says a local 911 operator took a call from an agitated local woman. "She said, 'I wouldn't have believed it if I hadn't seen it with my own eyes, but the whole mountain opened up and Air Force One flew in and it closed right up.'

Built at some point in the 1950s, Mount Weather is a vast underground city, bored out of basalt, with roofs reinforced by iron bolts, and as much

as 70 metres of reassuring rock above your head. The base was designed to be the ultimate bomb shelter from where the government could run whatever was left of its country after a nuclear holocaust.

It might have remained top secret, too, except that on 1 December, 1974, a TWA passenger flight crashed into the mountain, less than two kilometres from the Operations Centre.

Officials would only admit that it was a "secret government facility", but people began digging. An investigation published in 1976 said Mount Weather, kept secret even from much of the US Congress, was home to not only an emergency seat of power, but more than 100,000 secret files.

In 1991, *Time* magazine exposed Mount Weather as a vast underground lair humming with air-filtration systems that can extract dangerous fallout particles down to the size of microns. It's also home to a TV studio for post-Doomsday presidential broadcasts.

45.6011° N  
121.1828° W



### FORBIDDEN FACT!

The 'cool zone' in front of the racks of computers is kept at a balmy 28 degrees; Google staff therefore turn up to work in shorts and T-shirts.





VARIOUS LOCATIONS

# GOOGLE DATA CENTRES

## THE INTERNET GIANT'S INACCESSIBLE DATA LAIRS

**C**loud computing seems like a nebulous concept, with data floating all around us, waiting to be accessed, but the hard facts are that running the web requires hardware, and plenty of power to keep it all running. And cool.

Data centres, the physical repository of the web that binds us all, consume up to 1.5% of all the electricity produced on the planet, and by far the biggest owner of those centres is the internet behemoth Google. The world's pre-eminent search engine indexes 20 billion pages a day, and has data centres dotted all over the planet.

Not only is Google unwilling to say just how many of them it runs (it's believed there are more than a dozen, spread across the US, Europe

and Asia), until recently it was so secretive about the way they are constructed and run that no one from outside the company had even been allowed inside one.

In an unprecedented move, Google took its own Street View cameras inside one of its own locked-down data centres in the small, rural town of Lenoir, North Carolina, a huge building rammed full of thousands of computers built and conceived from the chips up by the search giant. With its futuristic cool-blue glow, it looked like a collection of the tractor-beam control units from the Death Star in the original *Star Wars*.

No single piece of data is stored in just one place, of course, so all the information collected by Google's digital spiders – which crawl over the

web seeking and sorting pages – is doubled up in case of disk failure.

These centres are not so much the lifeblood of Google as its veins, arteries and giant muscles, thousands of kilometres of optic fibre cable and thousands of servers. And because the company sees this network as its competitive advantage, it has always worked hard to protect its secrets.

Google also builds and perfects its own hardware, and has become one of the world's largest computer manufacturers, just on the basis of supplying its own networks. The company makes its own, stripped-down computers because it knows what it needs – speed and power – and what it doesn't. Graphics cards, for example, are useless because the servers don't even have screens.

### FORBIDDEN FACT!

Stalin's fear of assassination and attack led him to begin the Metro-2 project, with a line running from the Kremlin to his hideaway.



MOSCOW, RUSSIA

# METRO-2

PUTIN'S UNDERGROUND ESCAPE TUNNELS

**K**eeping a bunker, or even a small underground village, secret and secure is challenging enough, but the Russians – masters of espionage that they are – have kept a whole underground metro system hidden beneath the streets of Moscow.

Metro-2 was allegedly built by the fantastically paranoid Joseph Stalin, meaning it could date back as far as the 1920s, and was codenamed D-6 by the KGB. The secret railway is said to be even more extensive than the public Moscow Metro (which has 196 stations and runs for 327 kilometres), with four lines buried anywhere from 50 to 200 metres deep (the public metro is 74 metres at its deepest).

The lines – some of which were uncovered by a group called Diggers of the Underground Planet in 1994 – connect the Kremlin, head office of the KGB, with the Federal Security Service (FSB) headquarters, a VIP government airport called Vnukovo-2 and an underground town called Ramenki, plus various secret bunkers, for the use of the Politburo in times of war.

Unsurprisingly, neither Russia's FSB or Moscow Metro officials will confirm or deny the existence of Metro-2, but reports written by the US Department of Defense suggest that the Americans believe the rumours, and that the train lines are designed to take as many as 10,000 people to underground facilities

buried 300 metres underground in the event of nuclear war.

In 2008, Mikhail Poltoranin, a minister under Russian president Boris Yeltsin, confirmed the existence of “an extensive network of tunnels” connecting to an emergency command centre, from which the country’s nuclear arsenal could be controlled, as well as “branches that go to the suburbs so that the command could move away from the epicentre of a nuclear attack.” Other former government advisers, however, have suggested the scope and scale of the Metro-2 has been exaggerated, and that it has fallen into disrepair over the years and would not now be useful. But they would say that, wouldn’t they?

ATLANTA, USA

# THE COCA-COLA VAULT

## HOME OF THE PRICELESS FORMULA

Coca-Cola likes to keep its secrets in a very public way. The recipe for the gooey syrup that makes its borderline-addictive fizzy drink has been stored in a specially built vault since 2011. But that vault sits, not in a secure location, but at the World of Coca-Cola museum in Atlanta, US, and the public are invited to walk through it.

Described by the company as "the most closely guarded and best kept secret" in the world, the formula has been withheld from the slavering hands of Pepsi and other competitors since 1886, and now sits in a metal box locked

inside the purpose-built, high-tech, marketing-friendly facility in Atlanta. The vault never opens, and is protected by a keypad and a hand scanner, which may or may not be for show – Coca-Cola won't say.

The recipe was created in 1886 by a pharmacist called John S. Pemberton, who was so paranoid about it being copied that he never wrote it down, and shared it only with a few close-confidante colleagues. The formula for what was then described as a "brain tonic" initially contained a small amount of cocaine, which really got buyers hooked. But this highly active ingredient was removed in

1903, and replaced with caffeine. In 1919, when the company needed a bank loan, the secret formula was written on a piece of paper and used as collateral, such was its value. That printed formula was placed in a vault in the Guaranty Bank in New York until the loan was repaid in 1925.

Despite the fact that some people suggest the main ingredient is merely sugar, the formula has been feted as an industry secret of priceless worth for more than a century. And there's no denying its value today, when Coca-Cola sells 1.7 billion drinks a day around the globe. ▀

WORDS: Stephen Corby PHOTOS: Google Maps (8); Corbis (3); Getty Images (3); Alamy; PR



### MAGIC RECIPE

In 2011, a US couple claimed to have found a copy of Coke's secret formula [inset, above] in a box of old letters.

**FORBIDDEN FACT!**  
Coke doesn't actually contain kola nut extract, officially; the flavours are a combo of orange, lime, vanilla, cinnamon and nutmeg. And lots of sugar.

33.7628° N  
84.3928° W

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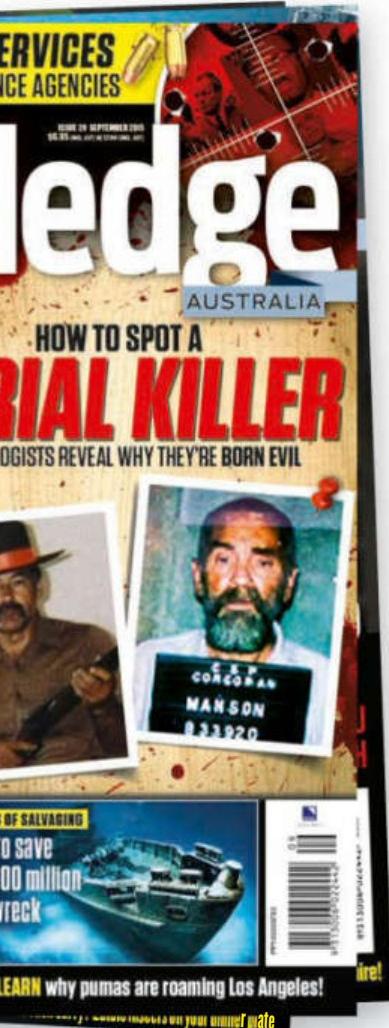


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NATURE

LATE RISER

In the mornings dragonflies can often be seen hanging, motionless, from plant stems. It's only as the sun comes up that they awaken from their cold-induced slumber and gradually reach their optimum working temperature.

LIVE FAST  
LOVE HARD  
DIE YOUNG

170 million years before the dinosaurs and an eternity before us humans, dragonflies were ruling the air. And they've hardly changed since, proving themselves to be champions of adaptation



## EAGLE EYE

Dragonflies' heads consist almost entirely of two huge compound eyes. They capture even the tiniest of details with crystal clarity – even from a distance of 40 metres. Good news for the dragonfly; bad news for this ladybird...

## FORCEPS

Once a dragonfly has decided on its target, it attacks the prey in midair. It uses its legs like a pair of forceps, fashioning a net that is impossible to escape from.

## PREY

Alongside ladybirds, the dragonfly's menu also features mosquitoes, flies and butterflies. Anything they can safely overpower, they attack indiscriminately – even members of their own species.





## COMBAT PILOT STRIKE RATE: 97%

» The carefree ladybird zips from leaf to leaf on the hunt for a little afternoon snack. But the creepy-crawly hasn't noticed the lethal hunter nearby that's sizing it up. At this precise moment the 30,000 lenses in its compound eyes are focused on the ladybird – reducing its chances of

survival to zero in one fell swoop. That's because the voracious predator waiting in the wings is a dragonfly. The ladybird stands no chance against this lightning-quick, agile attack machine. The dragonfly boasts a 97% strike rate – it's successful in almost every attack. Unless it starts to rain...

# 175 images per second I'M WATCHING YOU!

» Catching a dragonfly is nigh on impossible. The insects' compound eyes and rotating heads afford them near-360° vision and the temporal image resolution of their eyes is far superior to

ours. The insects are able to perceive even the quickest movements as if in slow motion. While we humans create just 20 individual images per second, dragonflies manage an impressive 175.



## CUTLERY

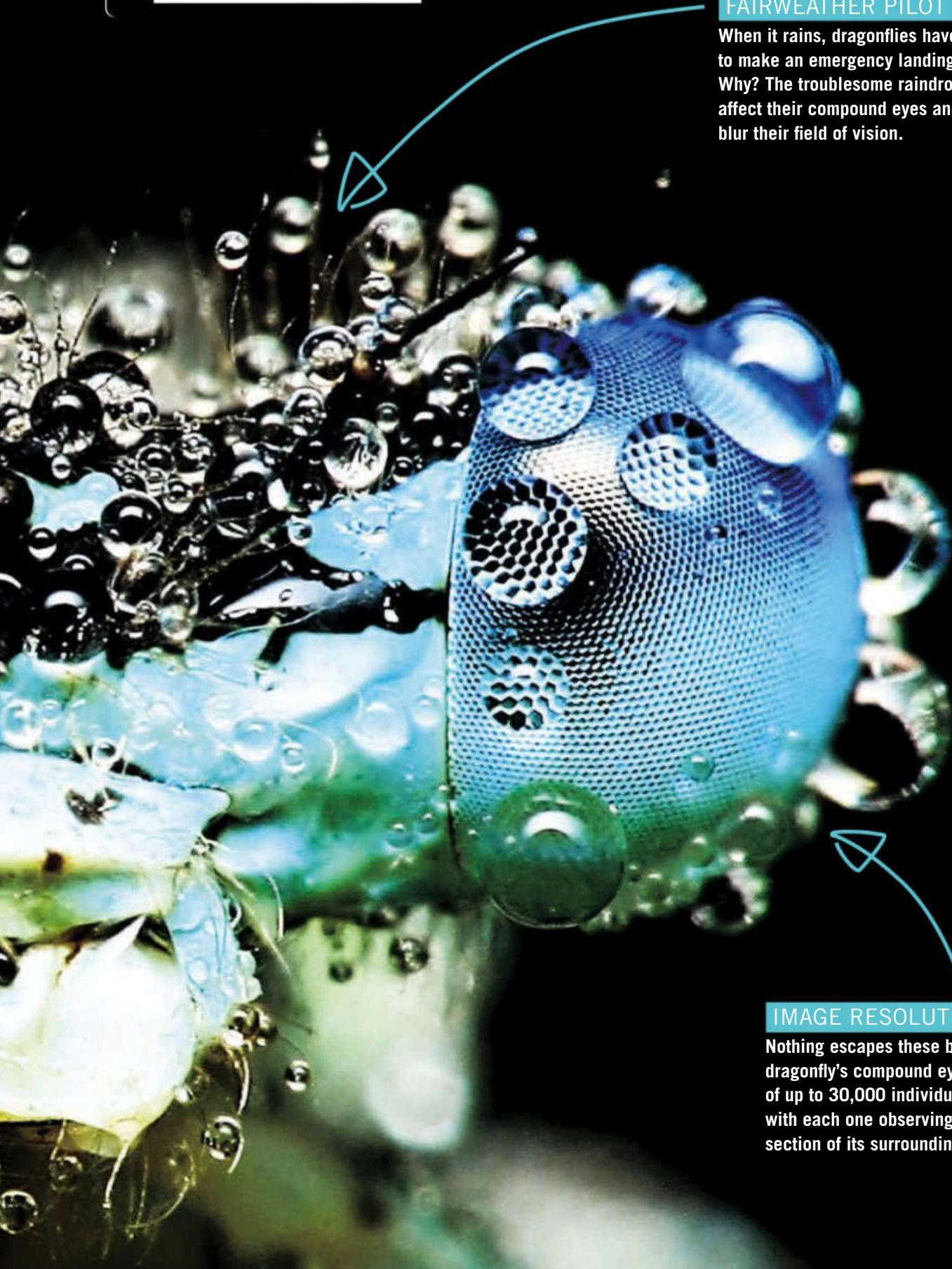
The dragonfly has sharp, powerful mouthparts. The lower jaw offers stability while the upper jaw chews food. Taste buds are located on the lower lip.



**PERFECT PREDATOR!**  
Use the free viewa app and scan  
this page to see incredible footage  
of a dragonfly hunting. And more!

### FAIRWEATHER PILOT

When it rains, dragonflies have  
to make an emergency landing.  
Why? The troublesome raindrops  
affect their compound eyes and  
blur their field of vision.



### IMAGE RESOLUTION

Nothing escapes these bugs: the  
dragonfly's compound eyes consist  
of up to 30,000 individual lenses,  
with each one observing a different  
section of its surroundings.

# S

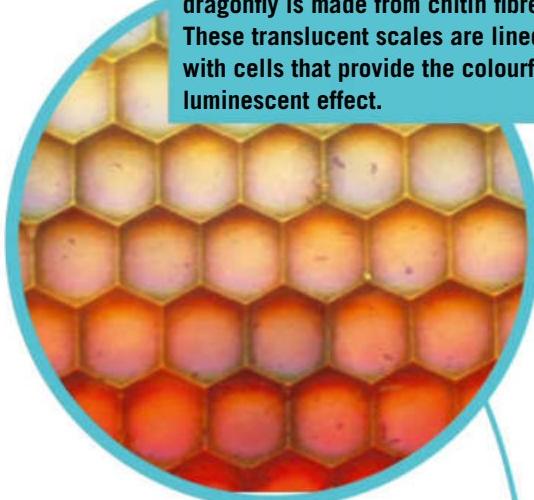
ilently the dragonfly zeroes in on its goal. It attacks from behind and beneath the enemy's blind spot, giving its victim no chance to escape before it's too late. Beating its wings 30 times every second, the dragonfly adjusts its position in the air according to where its prey is heading. To snatch food from the air requires highly complex flying skills and an ingenious technique that has previously only been observed in humans and vertebrates.

## CAN DRAGONFLIES INTERCEPT THEIR PREY?

The US researcher Anthony Leonardo discovered that dragonflies can anticipate the direction in which their prey will flee by steering their body into the projected flight path, even as their head and eyes still track the quarry in real-time. Accordingly, they adapt their head position before they swerve their bodies so that the prey always remains in sight. "The dragonfly doesn't fly in a completely straight line," says >

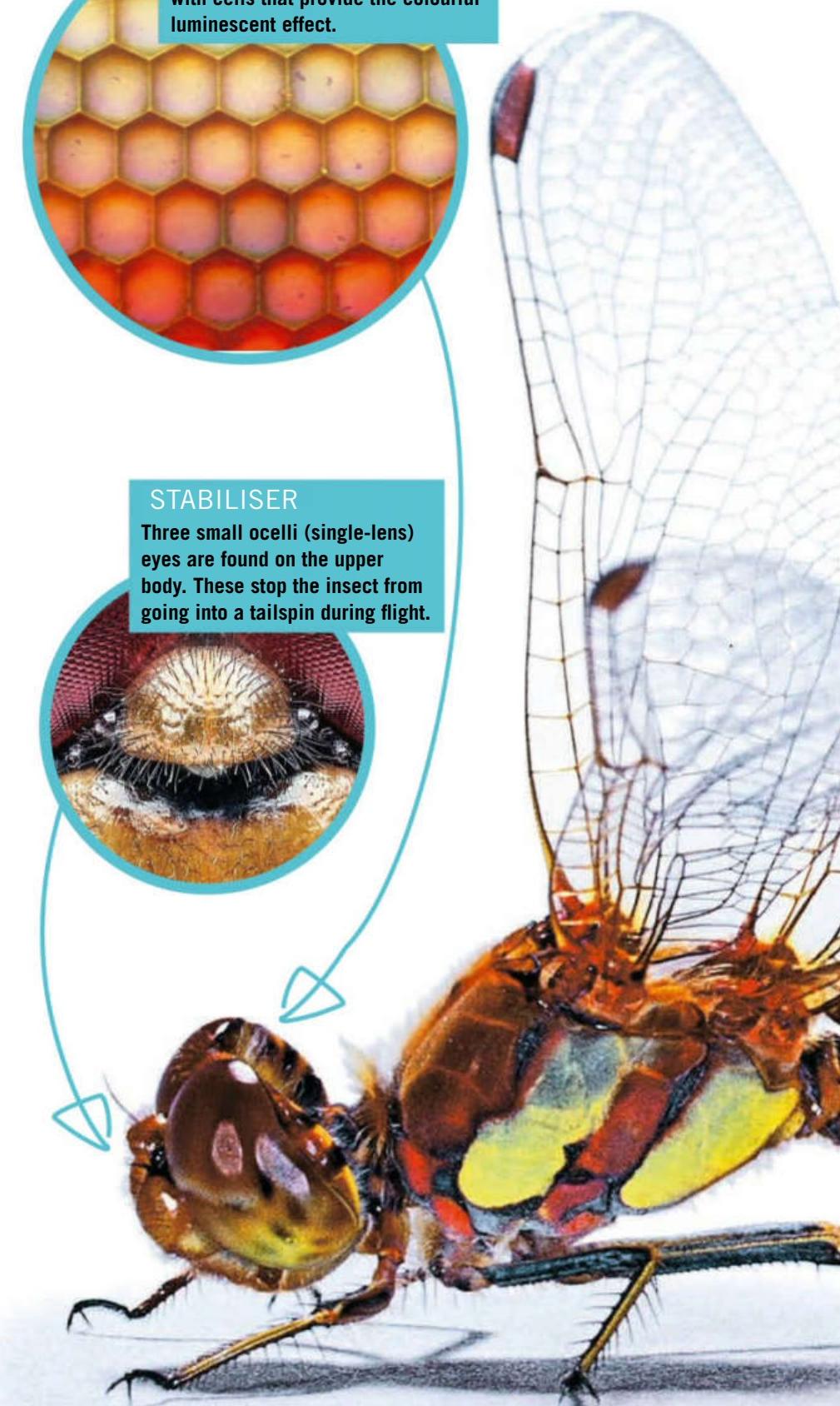
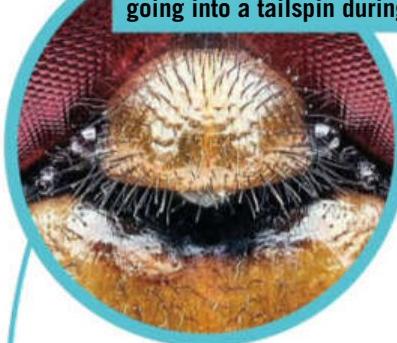
### SKIN ARMOUR

The outer skeleton (cuticula) of a dragonfly is made from chitin fibres. These translucent scales are lined with cells that provide the colourful luminescent effect.



### STABILISER

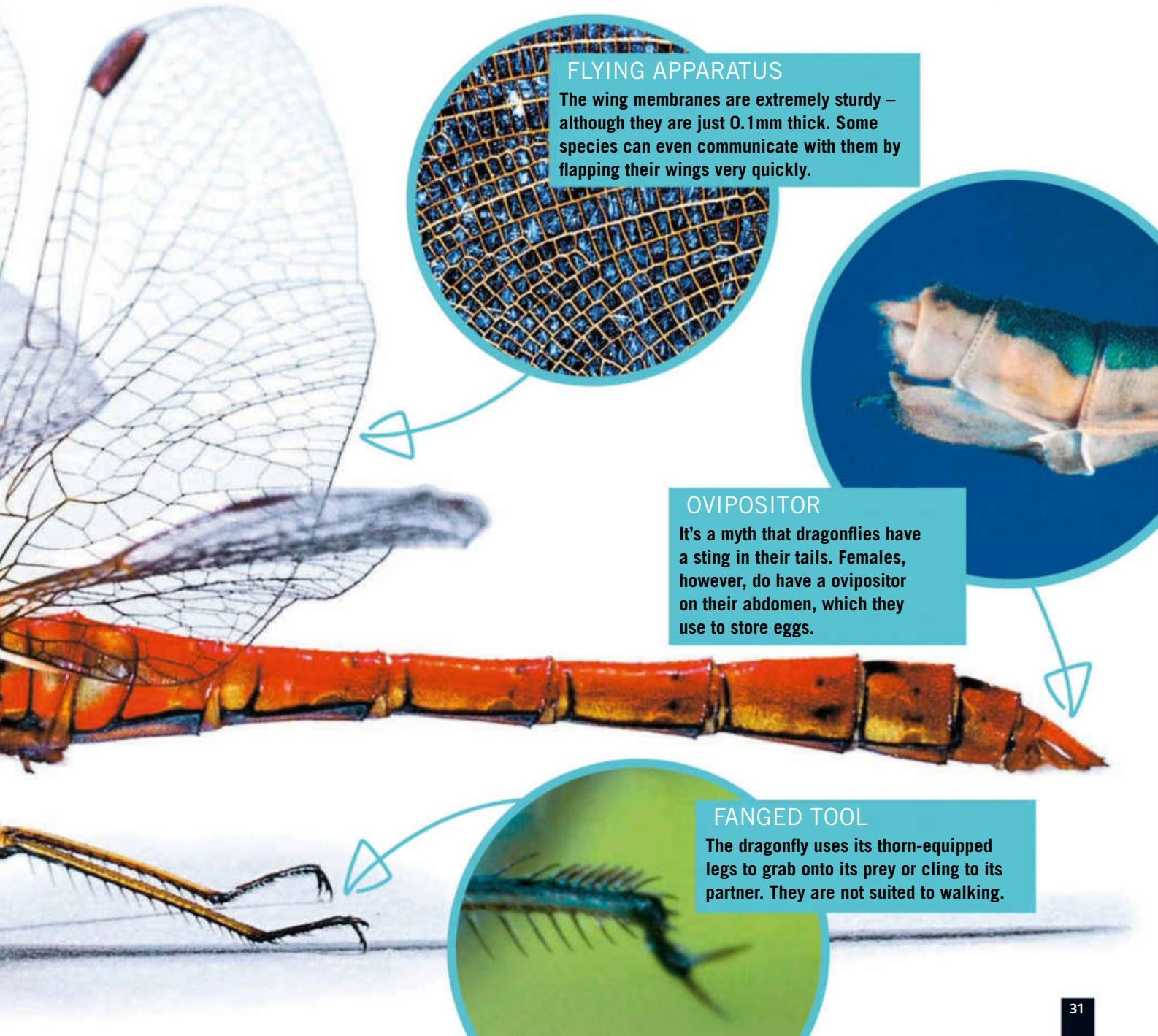
Three small ocelli (single-lens) eyes are found on the upper body. These stop the insect from going into a tailspin during flight.



# WELL-BALANCED

Almost every animal species has evolved over millions of years in order to better adapt to the changing climate – but the dragonfly is not among them. In evolutionary terms, the construction of its body was already perfect. Its large chest is perfectly balanced by its long, thin abdomen, which acts as a stabiliser, and each of its four wings can be controlled individually. Thanks to these adaptations dragonflies have been able to achieve record-breaking flights. Indian dragonflies surpass their European counterparts on that front: when migrating from

southern India over the Maldives and the Seychelles to east Africa, and back again, they travel over 18,000 kilometres. They're real experts in long-haul travel, racking up air mile after air mile. Meanwhile, a shield between the forehead and upper lip protects its sensitive compound eyes, which are a crucial part of the dragonfly's success. For good reason: sometimes males take part in ram raids to defend their territory. This sees them racing towards each other at full pelt. The rules? Whoever dodges a blow is the loser.



Leonardo. "Instead it is constantly adjusting its path to find the perfect position to catch its prey."

But before it becomes a flying attack machine, the dragonfly leads a shadowy existence. It spends up to five years as a carnivorous larva, hidden away in ponds and lakes. So fundamentally different is this life form from its later self that these early stages of development were once thought of as being a different species of insect. Hardly surprising when you consider the larvae breathe through special gills similar to fish. When their development is complete, they haul themselves onto a plant stem and squeeze themselves out of their larval skin. Half an hour later the dragonfly reaches its final size and can use its new wings to take its maiden flight. From then on it spends 95% of its day in the air – even eating while it flies, because the dragonfly has no time to lose.

Its motto for life in the fast lane: live fast, love hard, die young.

Alongside hunting and lolling around in the sun, there's one other thing on the dragonfly's mind: the continued existence of the species. Once it has found a suitable partner, the insects test their stamina for up to six hours in the 'mating wheel' – an extraordinary display that shows the true extent of a lover's union. Some couples remain loyal to each other even after mating, although given their relatively short lifespans that's no big commitment. The insects are only around for a few weeks, just time enough for them to lay their eggs before the summer ends.

### DO DRAGONFLIES HAVE A SPEEDOMETER?

Paradoxically, given their short lives, dragonflies are some of the oldest insects in the world. These graceful hunters were buzzing

around the Earth 320 million years ago, sharing the planet with massive prehistoric ferns and amphibians. Boasting a whopping 70cm wingspan, they were the undisputed rulers of the air – even today they hold the record for the biggest insect our planet has ever seen.

When it comes to flight, there's nothing to touch them: dragonflies are faster and more nimble than any other insect. Their muscles and joints are unique and considered to be some of the most complex in the entire animal kingdom. Crucial to their success are their four wings. The dragonfly can move each wing independently and at a different rhythm. Around 80 muscles allow each wing to beat in any desired direction. These 'propellers' allow dragonflies to carry out any number of stunts: they can hover in mid-air for up to a minute, change their direction in

## THE METAMORPHOSIS OF A DRAGONFLY



Dragonfly larvae spend a large part of their lives in water. Once they are fully grown, they leave their watery home and seek a suitable place to hatch so the process of metamorphosis can begin. As soon as they are no longer able to withstand the warm rays of the sun, the dragonfly

bursts out of its exoskeleton. It leaves its former life behind along with its old shell. Blood plasma is pumped around the body, helping its wings to unfurl. Before the newly hatched dragonfly buzzes off, it treats itself to a 30-minute sunbath. This allows the insect's armour to solidify fully.

### TRANSFORMATION

The larvae shed their skin up to 12 times in the one to two years before they finally leave the water to hatch.



a split second, twist, turn, sail on the breeze and even fly backwards. Once they've got a victim in their sights, everything happens at lightning speed: the nimble hunters accelerate from zero to 50km/h in

---

“The dragonfly is able to correct errors with **every beat of its wings.**”

ANTHONY LEONARDO, DRAGONFLY RESEARCHER



the space of a second and can reach 30 times the speed of the Earth's gravitational acceleration. Their short bristle-like antennae have been transformed during evolution. They measure air resistance and determine the speed of flight. The insects can even negotiate the tightest bends at top speed. In the process, ten times its bodyweight presses down on the dragonfly. And yet the master of the skies doesn't miss a beat.

The insects can even negotiate high winds. Given their delicate appearance, you'd think that physically impossible, but for these airborne maestros it's all a matter of technique. The muscles they use to fly are directly attached to their wings, which are further strengthened by a number of longitudinal veins. This means the largest dragonflies can reach heights of almost 2,000 metres, allowing them to fly above the strongest winds. At this extreme altitude, some species can reach top speeds of almost 100km/h and can fly thousands of kilometres. Their flexible heads serve as a navigation device and act as a rudder.



#### STALEMATE

This unusual position is known as the mating wheel. Endurance and stability are the name of the game here. While the male sits down, the female must dangle in the air.

#### WHEN DO DRAGONFLIES HAVE TO PERFORM AN EMERGENCY LANDING?

Of course, anyone that flies at such an altitude should always keep everything in view. Luckily, that's no problem for the dragonfly. Their compound eyes are actually made up of 30,000 individual eyes (called ommatidia) and are able to capture up to 175 images per second. They can also see a far wider spectrum of colours than humans.

But this super eye is not enough on its own: on its upper body, the dragonfly also has three so-called simple eyes, which have one lens to measure brightness and act as optical stabilisers. For ladybirds and the like, only one hope remains: a sudden summer downpour would really put a damper on the

dragonfly's acrobatics. You see, as soon as the first drops begin to fall, the insect's clear vision is impaired and any potential prey get an unexpected breather. The dragonfly can no longer determine its flightpath because the water confuses the compound eyes, making the landscape appear blurred. As a result, the dragonfly is forced to make an emergency landing.

As soon as the rain stops, it feverishly attempts to clean its 'windscreens'. Using the small hooks on its inner front legs, it wipes away dirt and water from the lenses. These useful 'windscreen wipers' are then locked into place on the back of the insect's head and the dragonfly can continue its patrol. The grace period for its prey has come to an abrupt end. **w**

**SERGIO CANAVERO:**

**"We are going to change the history of humankind."**

Grafting the head of a living person onto the body of a brain-dead donor – that's what Italian neurosurgeon Sergio Canavero from the Turin Advanced Neuromodulation Group hopes to achieve. "We now have the medical technology to succeed. The operation will be a success," says Canavero. "In a few decades, we'll be able to transplant the heads of sick people onto artificial bodies and even to clone entire humans."



# CAN YOUR BRAIN LIVE WITH A NEW BODY?

It sounds unbelievable, but it's true: in the next two years scientists hope to graft the head of a living patient onto the body of a brain-dead donor. The first volunteer for the operation has now been selected

**I** am prepared to take part in any and every experiment," says Valery Spiridonov. "After all, someone has to be the first." The 30-year-old Russian is applying for the chance to have his head separated from his body and transplanted onto another. He has now been chosen from hundreds of applicants to be the first to undergo the procedure. The operation will take place by 2017 – and will mark the greatest surgical adventure of modern times. The surgery is already considered one of the most controversial

of the modern transplantation technologies: depending on the outcome, it could mutate into a medical dream – or a nightmare. What kind of patient would be eligible for the operation? And what would a success mean for the future of medicine? Could people thought of as having an incurable illness survive the operation?

**To carry out a head transplant you need 100 doctors, 36 hours and \$18 million**

Since birth Valery Spiridonov has been suffering from an incurable muscle-wasting disease called spinal muscular atrophy. He is

unable to walk or stand without assistance. Most people with this disease die before their 20th birthday. The head transplant could save his life. "It's people like Valery that this procedure is for," explains Sergio Canavero, the Italian surgeon who will lead the operation. Around 100 surgeons will be involved in the 36-hour operation, which will cost \$18 million. But what risks does the operation pose? Could a brain and a heart from different bodies really work together?

The body will be taken from a brain-dead donor. Prerequisites? The recipient's build and immune system must match that of the donor. First, Spiridov's head and

&gt;

# HOW WILL THE TRANSPLANT WORK?

**A**t some point in the next two years, Sergio Canavero and a team of 100 surgeons hope to graft the head of patient Valery Spiridonov onto the body of a brain-dead donor in the world's first head transplant operation. The surgery has already been planned in minute detail. Some steps have already been individually tested, like the cooling of organs and body tissues, while others represent an entirely new challenge for the doctors.

## STANDSTILL

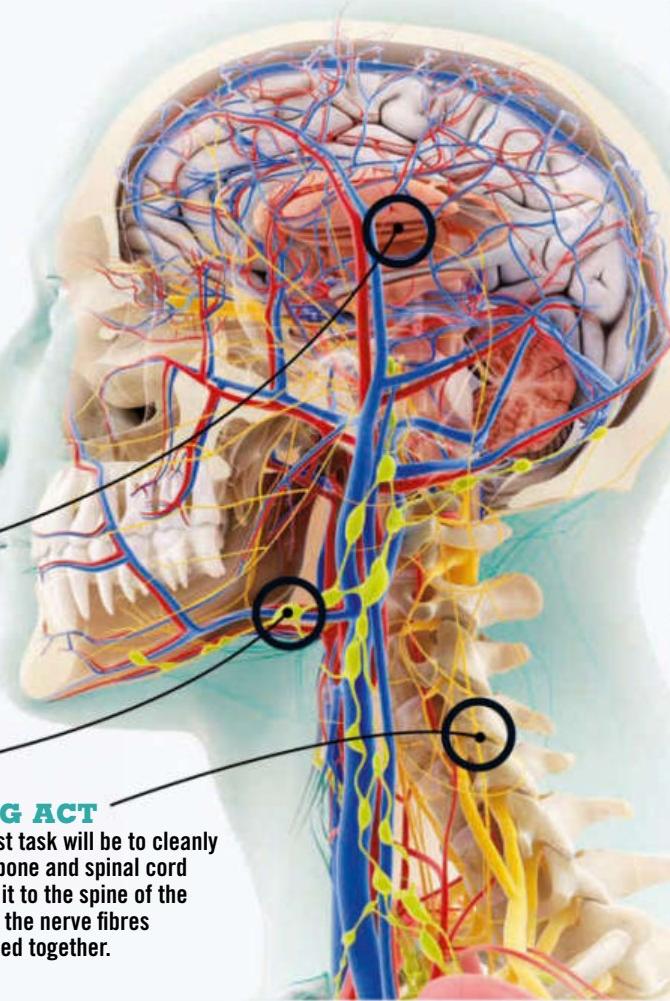
The patient will not be conscious during the operation: after being placed under general anaesthetic, the head is cooled using a cooling cap to 10 degrees Celsius. This puts brain activity on hold. It's only reactivated when the warm blood from the donor's body begins to flow through to the donor's brain.

## DEFENCE

The lymphatic system will also be connected to the new body. The patient will have to take immunosuppressant drugs after the operation to lower the risk of rejection.

## BALANCING ACT

Canavero's trickiest task will be to cleanly separate the backbone and spinal cord before connecting it to the spine of the donor body so that the nerve fibres (yellow) can be fused together.



spinal cord will be cooled to 10 degrees Celsius so that his cells survive the operation. Then the surgeons will begin the painstaking task of separating the skin and muscles in the neck and spinal cord using an exceptionally sharp knife to minimise nerve damage. There's a one-hour window for connecting

Spiridonov's head onto the new body. Using a chemical adhesive, Canavero will then fuse the two bundles of nerve fibres at either end of the spinal cord. Then the blood vessels, muscles and skin are sewn back together. The blood from the donated body will immediately begin to flow into Spiridonov's

head, which will begin to warm up. Once it receives enough oxygen, the brain will be reactivated.

## THE IMMUNE SYSTEM IS A PATIENT'S BIGGEST ENEMY

The patient is kept in an artificial coma for up to four weeks. If all goes to plan, Canavero hopes that Spiridonov will be walking within a year – and may eventually lead a normal life. But many other doctors have their doubts, and aren't afraid to voice their concerns.

"I don't believe it will ever work," says Harry Goldsmith, clinical professor of neurological surgery at the University of California. "Trying to keep someone healthy in a coma for four weeks – it's not going to happen." Previous experiments have failed: in 1970, doctors grafted the head of a monkey onto the



## VALERY SPIRIDONOV: "I don't have much time left..."

● A full-body transplant is the 30-year-old's last chance: Valery Spiridonov has suffered from a muscular atrophy disease since birth. He has never walked. "I know that my condition will only get worse," he explains. "That's why I applied to be the first to undergo the procedure."



#### MIRACLE WEAPON

## How do you glue nerves together?

● Were the head transplant to succeed, it would be an astonishing surgical feat. To ensure the patient is not paralysed after the transplant, Canavero must reconnect the nerve fibres in the spinal cord [left] with those in the donor's body. To do so he plans to use a chemical adhesive: polyethylene glycol (PEG). PEG alters fatty structures in the cell walls so that the cells are better able to bind to one another. Tests on paraplegic rats have already been successful.

body of another ape. It died after nine days because its head was rejected by its new body.

"Surgery has moved on a lot since then," says Canavero. One serious issue is overcoming the donor body's immune system. After the transplant, the patient will be given immuno-suppressant drugs. "The system we have for preventing immune rejection and the principles behind it are well established," stresses William Matthews from the American Academy of Neurological and Orthopaedic Surgeons.

But the biggest hurdle will be reconstructing the millions of central nerve fibres that are not usually capable of regenerating. Damaged fibres rarely rejoin. To counteract this, Canavero plans to inject the spinal cord with a chemical fluid called polyethylene

glycol that may help nervous tissue fuse together more quickly. Spiridonov's nerves will be stimulated with electrical impulses during the coma phase. This will encourage the formation of new connections. If neither of these methods works, Canavero plans to inject stem cells or glia cells into the spinal cord. Both of these types of cells are able to repair and regenerate damaged tissue.

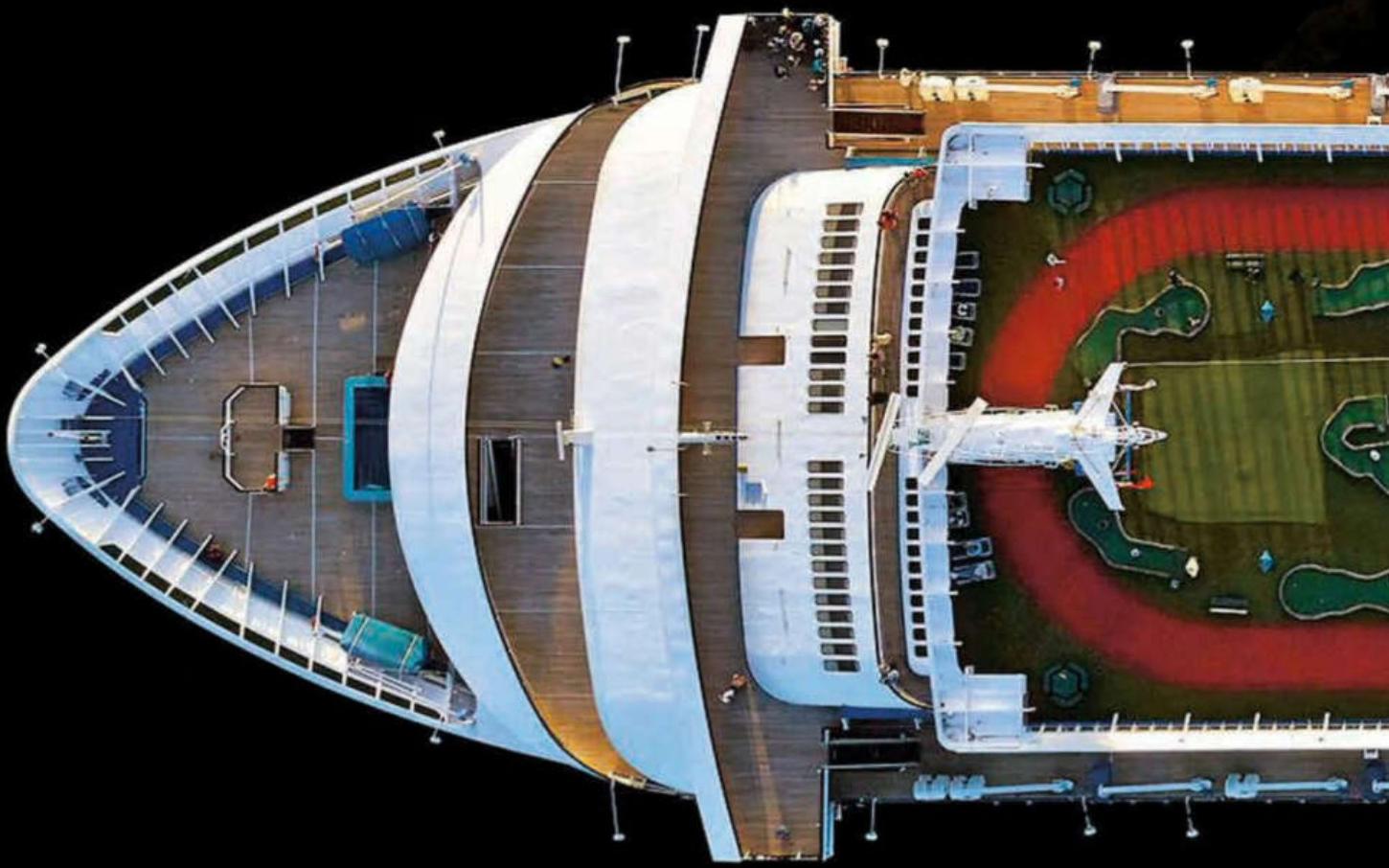
### Can a new body change your psyche?

Ground-breaking innovations have always initially attracted criticism in the medical field; 1967 saw the world's first successful heart transplant, even though many doctors had thought it impossible. "That's how you revolutionise medicine," says Canavero. "With

new techniques, we will be able to cure the incurable!"

But what is the biggest fear among doctors? Many worry that the op could affect the patient's personality. Some people report feeling ill at ease in their own body after a face or limb transplant. Some heart transplant patients say their interests and personality change after the operation. Nobody can say for sure how Spiridonov may be affected. "The brain of the recipient is in control, but the body is foreign, says Canavero. "And if the patient has children later on, they will have the donor's genes."

"This operation is an experiment," says Spiridonov. "Without it I won't live much longer. It will help doctors to perfect complex procedures, which will help future generations. It's absolutely worth it." **W**



No witnesses, no police, no clues: every year, around 20 people disappear from cruise liners. Look beyond the happy holidaymakers and you'll find every criminologist's worst nightmare

# THE PERFECT CRIMES

MS Carnival Sensation



“People go on ships and are lulled into a false sense of security because they are happy places full of holidaymakers. **Crimes are swept under the carpet** and incidents are not investigated properly.”

*Mike Coriam*

Father of vanished crew member Rebecca Coriam

# SCENE

MS Carnival Sensation



**SOS**  
Carrying a maximum 2,056 passengers and 920 crew members, the Carnival Sensation has the same capacity as most average-sized cruise liners. In an emergency everyone on board must be able to be evacuated using the lifeboats within 30 minutes.

Since the year 2000 more than 250 people have fallen overboard on cruise ships. **Only about one in five can be saved.** The reason why passengers disappear usually remains a mystery.

MS Freedom Of The Seas



**LEVIATHAN**  
Up until 2009 the Freedom Of The Seas, was the biggest cruise ship in the world, capable of holding 3,782 passengers. Six engines with a combined horsepower of more than 100,000 allow it to reach a speed of 21 knots. There's also a helipad where air ambulances can land in an emergency.

#### HOMELAND

As is the case on most cruise ships, the flag of the Bahamas flies from the stern of this boat. The Caribbean state is popular with shipping companies thanks to its relaxed laws.

#### WAVE SURFER

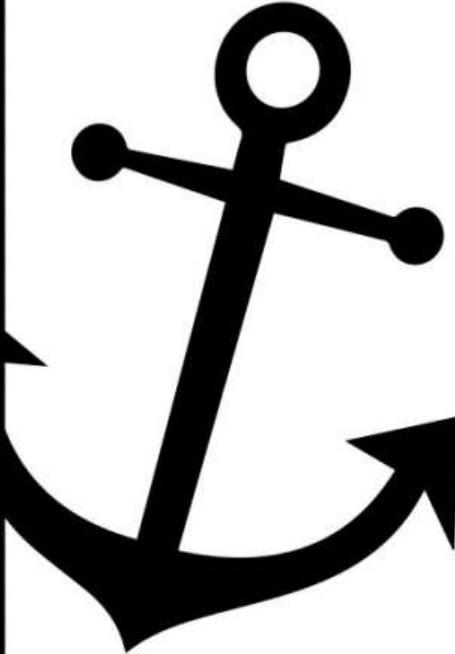
On the stern of the 18-storey ship there's a pool where surfers can ride a stationary wave. 50 metres below the upper deck are the waves of the ocean itself – a fall from this height would almost certainly be fatal.



MS Norwegian Sky

### VANISHED

On 18th April 2009, at about three in the morning, a 39-year-old man disappeared from the Norwegian Sky close to the Bahamas. After 16 hours the search for him was called off.



Imagine a city that houses more than 8,000 people from around the world. A city where there are 18 times more people per square metre than in Manhattan. A place where people from different sections of society interact every day. Where there's a rubbish depot, a sewage treatment plant, a hospital, a supermarket, amusement parks, alcohol – but not a single policeman. A city that is absent from all world maps, but exists as a dubious mini-state, the equivalent of an overseas territory. A parallel world like this can't exist, can it? Quite the contrary. Around 300 of these cities are currently in existence and every year around a dozen more are added to this number. Almost a million people are living in these cities as we speak: on cruise ships.

None is bigger than the Allure Of The Seas, currently the world's largest, but they all have something in common: it's easier to commit a murder on these floating multinational palaces than anywhere else in the entire world.

### WHY ARE THERE NO POLICE AT SEA?

It is shortly before ten at night when Annette Mizener leaves her cabin and makes her way to the casino.

But the 37-year-old never reaches her destination on board the cruise ship The Pride. Instead her handbag turns up, with beads from her beaded purse scattered on the deck – next to a drop of blood. The signs of a struggle? We'll never know: a CCTV camera that could have captured what happened had been covered with a map of the boat just before the crime. To this day, more than ten years later, Mizener is considered lost without a trace.

Just like Annette Mizener, around 20 people a year disappear on the high seas during a cruise. Without a trace. Without a farewell note, often without witnesses. Their fate is frequently sealed in the early hours of the morning on deck, somewhere between corridor and cabin. They remain lost forever. The causes can only be speculated upon – often the disappearances are automatically categorised as suicide or an accident. But is that really true?

"These cases are hardly ever investigated," says Kendall Carver, founder of the self-help organisation International Cruise Victims, whose daughter Merrian disappeared at sea in 2004. "The bosses of the big ships, who are responsible for thousands of passengers, are not even obliged to write a report." After the disappearance of a loved one, a second nightmare begins for those left behind. When a crime happens on land, it's natural to turn to the police. But at sea there is no such authority. Mark Brimble is keenly aware of this – his ex-wife died in unexplained circumstances on board the Pacific Sky. "You step onto a boat that is registered in Bermuda, the shipping company is in London and the suspect is from New Zealand. It's a total black hole, in terms of which laws should be applied and who investigates."

**"A cruise is the perfect place to commit the perfect crime."**

*Christopher Shays,  
former US representative*

#### **HOW MANY PEOPLE GO OVERBOARD EVERY YEAR?**

Most passengers think that they are protected by their state when they go on board – usually because their ship departs from a port in their home country. But, seen from a purely legal perspective, they are often taken on a journey to another continent when they step on board. Outside territorial waters, around 20 kilometres from the coast, they leave their state's sphere of influence. "They are then in the hands of whichever state's flag is flying from the stern," explains Birgit Feldtmann, from the Department of Law at the University of Southern Denmark. The most common flag is that of the Bahamas, a small tax haven in the Caribbean, where the

## FALL INTO DARKNESS



Shortly after midnight, after drinking large quantities of alcohol, Sarah Kirby fell into the Atlantic from the seventh storey of the Carnival Destiny. Having sustained numerous broken bones after hitting a lifeboat on the way down, she fought for her life – successfully. Kirby was saved after another passenger saw her fall and the Carnival's captain led a rescue mission. An infrared CCTV camera captured the drama live on video, but Kirby still spent two hours in the water.



(registered) murder rate is 29.8 per 100,000 residents. The island nation is 13th in a list of countries with the highest crime rates. "As a rule of thumb, the local authorities are not in a position to contribute to an investigation of a crime," explains Kendall Carver.

In the case of crew member Rebecca Coriam from Chester, UK, only one detective was assigned to look into her disappearance from the Disney Wonder in 2011 – even though the crime scene spanned 11 floors, with 3,500 potential witnesses. "The detective questioned just a few crew members. We will never know the truth," says Rebecca Coriam's father, Mike.

For criminals these sorts of conditions are an invitation – they need only to lure their victim on a sea voyage. Then a simple fall from ten metres above the water's

surface is sufficient to make it look like a tragic accident. And if the fall is from a height of more than 50 metres, the chances of survival sink to zero. Even if the captain sounds the alarm immediately, it takes at least a 1.6km for an ocean giant weighing 100,000 tons and travelling at full speed to come to a halt. A search at night is already a difficult enough undertaking. But as a rule, it is usually a few hours before the disappearance of a passenger is noticed. Travelling at a speed of 20-25 knots, this delay can quickly widen the search zone to an area double the size of Sydney.

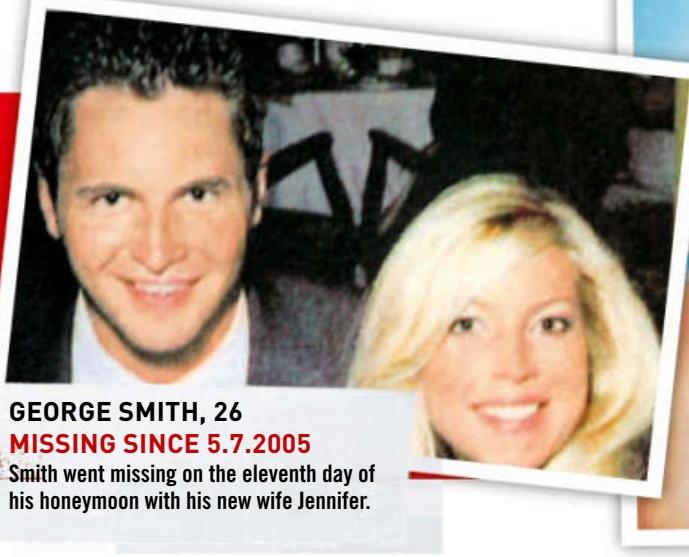
Since 2000, more than 250 people have fallen overboard on passenger ships – and only one in five has been rescued. The others remain lost without a trace. Jim Walker, an American lawyer and critic of the cruise industry, bemoans the

PHOTOS: Action Press (3); PR (6)

## WHAT REALLY HAPPENED?

**George Allen Smith** is enjoying his honeymoon: he and his wife Jennifer have been married exactly 11 days. The couple [right] were on a Mediterranean cruise aboard the Brilliance Of The Seas. The American disappeared on the evening of 5th July 2005 and smears of blood were found in his cabin as well as on the walls on deck. The FBI investigated two Russians on suspicion of murder.

Smith's wife suspected an accident – but there are claims the cruise company bought her silence with a \$1.1 million compensation payment. The background to the incident remains unexplained. Accident, suicide or murder – George Smith joined the long list of victims who have disappeared from cruise liners in suspicious circumstances that have never been explained.



**GEORGE SMITH, 26  
MISSING SINCE 5.7.2005**

Smith went missing on the eleventh day of his honeymoon with his new wife Jennifer.



lack of investigations into such occurrences. "I would estimate that alcohol is in play in about 40% of these cases. Ten per cent are suicide. The other 50% remain a mystery – often there is criminal intent. The most likely scenarios are men who throw their wives or girlfriends overboard."

#### IS THERE A CODE OF SILENCE AT SEA?

"A cruise is the perfect place to commit the perfect crime," says US politician Christopher Shays, who campaigns for the safety of cruise passengers. On a ship, a murderer's biggest problem – disposing of the body without arousing suspicion – takes care of itself. "You don't need a major weapon, and your evidence disappears," Shays continues.

And instead of investigating these incidents, some cruise companies

try to suppress reports of possible crimes. The cruise industry is so lucrative that it will do anything to avoid negative headlines. Around 20 million people go on cruises every year, spending on average about \$250 per day. "The most important thing is selling holidays, not guaranteeing passenger safety. Those responsible cover it up for as long as they can," says personal injury lawyer Philip M. Gerson, who specialises in accidents on cruise ships among other things. "Traditionally the cruise industry has avoided or stalled on registering a missing person so as not to endanger their carefully constructed image of safety."

#### WHO INVESTIGATES CRIMES ON THE OCEAN?

Different rules apply when selecting a detective or police officer to

investigate possible crimes at sea because when the shipping company chooses a ship's 'nationality', they also determine which investigative authorities have jurisdiction in an emergency. And because this out-flagging usually proceeds without any problems, the flag states have no reason to kick up a fuss.

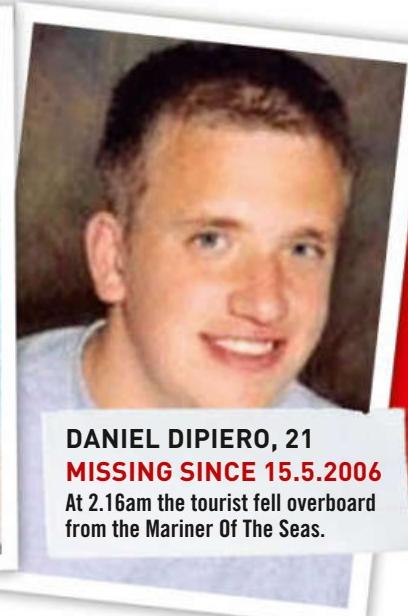
Thanks to the pressure exerted by organisations set up to support the relatives of vanished passengers, covering up the truth is getting more difficult. Since 2010, cruise ships calling at American ports must report certain crimes. These include robbery when a theft of more than \$10,000 has occurred, attacks where injuries are inflicted, or the disappearance of passengers and crew. The police and the FBI now have the right to investigate on board – but only if US citizens are involved. Since this change in the law, the number of registered crimes has risen 30-fold.

The fact remains that one in one million passengers disappears. Admittedly, that's a tiny percentage – but Ross A. Klein, a cruise expert and professor at the Memorial University of Newfoundland, suspects the real number is probably far higher. And for people without relatives, or crew members from countries without functioning legal systems, there's no opportunity to demand a proper investigation. Suspicion haunts each and every case. **W**



**REBECCA CORIAM, 24  
MISSING SINCE 22.3.2011**

The crew member was last seen on board the Disney Wonder at 5.45am.



**DANIEL DIPERO, 21  
MISSING SINCE 15.5.2006**

At 2.16am the tourist fell overboard from the Mariner Of The Seas.

# ASH APOCALYPSE

Unpredictable, destructive and unstoppable – volcanoes are among the most powerful natural forces on Earth. But it's not the tons of lava streaming down a volcano's sides that makes them so dangerous. The real danger is their ash



## KILLER CLOUDS!

Use the free viewa app and scan this page to see a Japanese volcano spewing its deadly ash. And more!



## Can an avalanche of ash vaporise a human?

A fast-moving current of gas, rock and ash known as a pyroclastic flow destroys everything its in path on the way down from the summit: in this avalanche-like inferno of ash, temperatures can reach 800 degrees Celsius – enough heat to vaporise 90% of a human body in a flash. But even when cold, the ash remains dangerous: the ultra-fine particles, often measuring mere nanometres, can stick to our lungs when we inhale. Fourteen people died as a result of this during the eruption of Indonesia's Mount Sinabung on 1st February 2014 [pictured]. The volcano lies just 34 kilometres away from Toba – the same volcano that pushed mankind to the brink of extinction 70,000 years ago.

A photograph capturing a moment of intense volcanic activity. In the foreground, a person wearing a light-colored shirt and dark pants stands by the open door of a vehicle, looking towards the right where a massive, dark grey and black plume of smoke and ash rises into the sky. The sky is filled with the billowing clouds of the eruption. The scene is set outdoors, likely in a rural or agricultural area, with some greenery visible in the lower right corner.

## How does a volcano break the sound barrier?

Pyroclastic clouds can reach the speed of sound during an eruption – that's around 1,225km/h. Their direction is crucial: during a horizontal eruption, the window to warn people to get away from the area plummets to mere seconds. In this photo, the Sinabung volcano is shooting towards the sky, which affords the farmers valuable minutes: they frantically harvest their fields as the ash can fall to Earth at any time. Even a 20mm layer of dust is enough to destroy entire harvests, suffocating the plants.



# A

nywhere between 30 seconds and ten minutes, depending on how far away you are. That's how little time you've got left once you hear the volcano explode on the mountaintop – and you find yourself in the path of the pyroclastic flow.

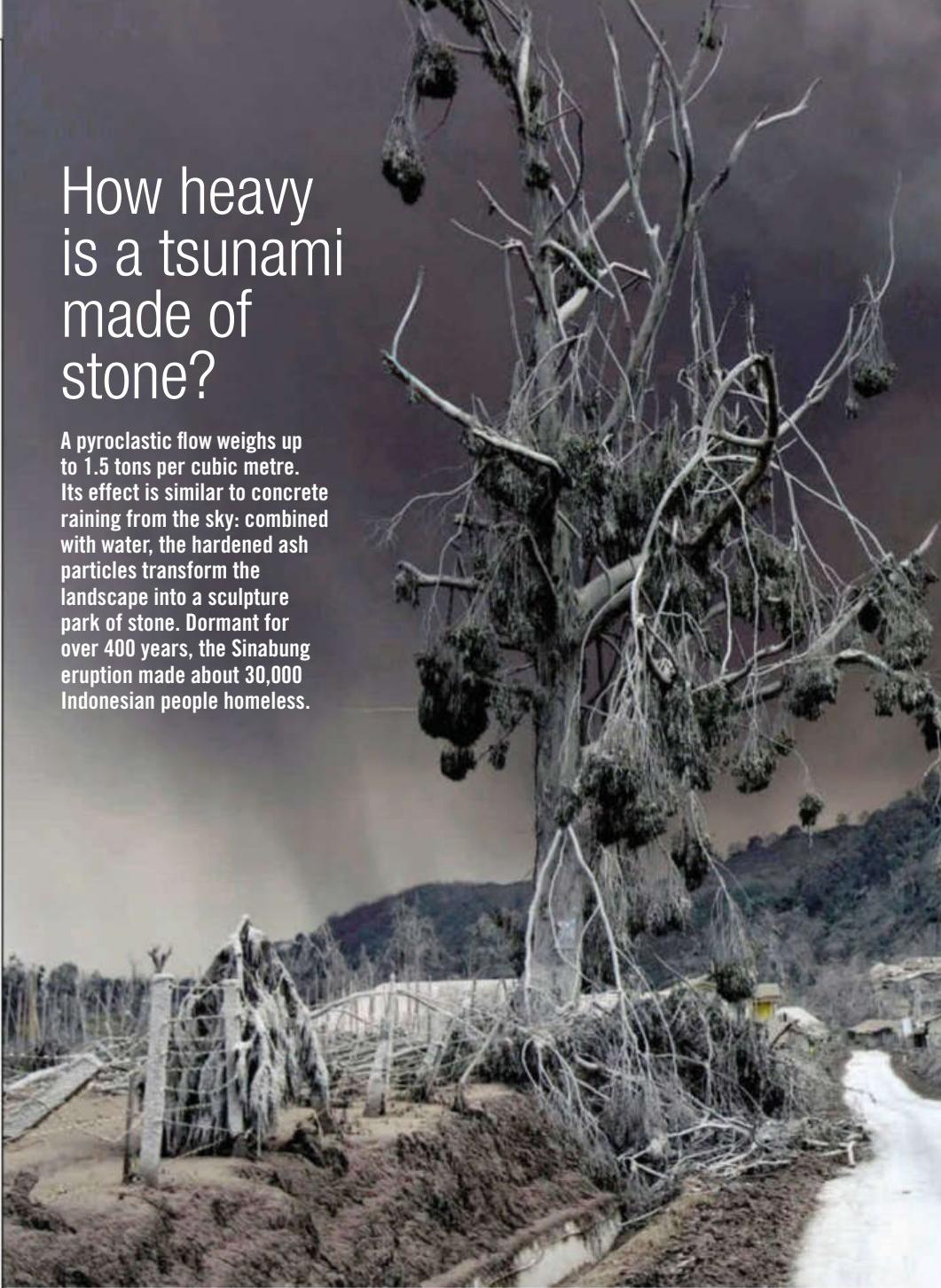
The phenomena that occurs at this moment can be compared to the uncorking of a gigantic, boiling hot bottle of champagne: as soon as the pressure of the Earth's crust on the magma streaming upwards subsides, the gases dissolved within the magma are released. The melted rock – weighing many tons and clocking in at around 1,300 degrees Celsius – explodes at the surface.

In a split second, a single litre of water transforms into 1,244 litres of water vapour. The mixture of gas and nanometre-thin ash particles shoots miles-high up into the atmosphere, before collapsing under its own weight and finally tumbling back down the side of the mountain at speeds of up to 700 kilometres per hour – more than double those of a cyclone. Temperatures of up to 800 degrees Celsius are the norm in the blisteringly hot cloud – enough heat to vaporise a human, leaving behind just bones and teeth.

And this is 'only' the ash cloud – in some cases not a single drop of lava has bubbled over the edge of the crater at this point.

## How heavy is a tsunami made of stone?

A pyroclastic flow weighs up to 1.5 tons per cubic metre. Its effect is similar to concrete raining from the sky: combined with water, the hardened ash particles transform the landscape into a sculpture park of stone. Dormant for over 400 years, the Sinabung eruption made about 30,000 Indonesian people homeless.



### HOW DOES A CYCLONE OF ROCK FUNCTION?

A pyroclastic flow (Greek for 'fragmented fire') is one of the most violent natural phenomena. While the quickest lava reaches just 65 kilometres per hour, allowing its route to be predicted fairly accurately, scientists have observed ash clouds that have expanded faster than the speed of sound. This makes ash not only faster and more powerful than

a cyclone – but also many times more destructive. The scorching cloud made up of hot gas and rock fragments, collectively known as tephra, maintains its high temperature even 40 kilometres from the peak of the mountain. The heat remains constant because in contrast to the Earth's interior, the volcanic gases at the surface burn when they come into contact with oxygen and keep the pyroclastic flow hot – even when it is on the move.



The current of lava destroys everything in its path. The avalanche-like inferno lasts no more than two to five minutes, but in that time forests and cities are wiped out and the remains completely covered in dust. Even modern buildings struggle to withstand the tsunami of gas and ash. Bodies of water don't provide a safe haven either. In fact, a pyroclastic flow becomes even more dangerous for humans when it approaches over water. Because without the usual burning

or explosive noises, the wave moves forwards almost silently. So if you're far away and believe yourself to be safe, you might be in for a nasty surprise. During the night or in foggy conditions, advanced warning of the pyroclastic flow's arrival is pretty much impossible.

### CAN A HUMAN BODY EXPLODE AS A RESULT OF HEAT?

Approximately 78% nitrogen, 21% oxygen – and very little of anything

else. That's the gas mixture that our lungs work with. At the same time they require a temperature of between 24 and 45 degrees Celsius to function. If the organ exceeds these narrow margins, even for just a brief period, the body can collapse within seconds. And a pyroclastic flow attacks this delicate balance on several levels.

To survive a cyclone in the open is considered a miracle. Surviving a cyclone consisting of countless tiny rocks instead of wind is pretty

much impossible. From one second to the next, the moving ash turns the air darker than even the blackest of nights. With every panicky breath, more of the sharp-edged particles slice through the lungs. In seconds the temperature rises by several hundred degrees. Even screaming is nigh on impossible by this point – the searing hot gas has already burned the vocal chords. As a result of the violent boiling of water into steam, scorching gas in the lungs at a temperatures of 500 degrees Celsius is enough to make a human body explode.

## CAN A VOLCANO DROP 170,000 ATOMIC BOMBS?

The devastation wrought by pyroclastic flows is extensive and long-lasting: the ash cloud's fire robs the air of the oxygen vital to life and instead replaces it with toxic hydrogen sulphide. When these substances come into

contact with water molecules, they become poisonous acids and burn the soil. Fine dust is deposited up to a height of several metres, suffocating all form of life. Even a layer just two centimetres thick would be enough to destroy the harvest of an entire region.

The first signs of an eruption usually still seem harmless. Take the Indonesian volcano Tambora, which awoke for the first time in over a thousand years in 1812. Ash clouds formed over the summit, but most of the locals didn't know anything about its volcanic activity and carried on their business as normal.

Then, three years later on 5th April 1815, there was a sudden explosion that shot ash 30 kilometres into the air. Five days after that, the upper 1,500 metres of the mountain was torn open and the resulting bang heard as far as 2,600 kilometres away – that's around three times the distance between Melbourne and

Sydney. The power of the eruption was extraordinary, equivalent to 170,000 of the nuclear bombs dropped over Hiroshima. A huge crater, 6.5 kilometres wide and 100 metres deep, was torn open.

Tambora ejected roughly 140 billion tons of material – the same weight as 1.5 million aircraft carriers. The resulting pyroclastic flow spread out across an area of at least 20 kilometres in all directions. Night reigned for two days in an area spanning 1,000 kilometres. For a year the ash darkened the sky – even in Europe and America. Failed harvests and famine followed. During the most powerful volcanic eruption of the past 20,000 years, at least 70,000 people lost their lives.

## WHY IS A SLEEPING GIANT MORE DANGEROUS THAN THE BIGGEST VOLCANO

There are roughly 1,500 active volcanoes around the world. The

### RUNNING FOR HER LIFE

The pyroclastic flow of Indonesia's Mount Sinabung thunders down into the valley behind this woman, completely destroying the village there.



ferocity of their eruptions depends predominantly on the condition of the magma – their source of energy. The quantity of silicic acid contained within is crucial: the more silicic acid it contains, the thicker the magma is. And the thicker it is, the harder it is for the gases within to escape to the outside. Thus the more explosive the mixture becomes. It's common for erupting, or even just bubbling, volcanoes to be constantly relieving pressure from their depths.

Mauna Loa volcano and its neighbours in Hawaii count among some of the biggest volcanoes on Earth and sometimes erupt for decades without pause – though not

The biggest volcanic eruption of the past 20,000 years spewed out around 140 billion tons of ash and rock. That's equivalent to the mass of 1.5 million aircraft carriers.

normally on a catastrophic level. Their volcanic explosivity index (VEI) – a measure of the force of an eruption – lies at 0 or 1. Markedly more dangerous are the dormant sleepers, those volcanoes that have been silent for thousands, sometimes even tens of thousands, of years. Mount Tambora, one of the biggest eruptions in recorded history, reached a VEI strength of 7. Scientists believe the impact of an eruption with a VEI of 8 would be "apocalyptic". Statistically speaking, one of these happens only once every 10,000 years. The last time one took place was 26,500 years ago in New Zealand. So a VEI 8 is long overdue – by 16,715 years. **W**

# ANATOMY OF A DISASTER

Plinian eruptions, named after Pliny the Younger, who described the eruption of Mount Vesuvius in AD 79, are the largest and most violent of all types of volcanic eruption. Several cubic kilometres of ash and other material can reach the surface within hours, destroying all life over a radius of several hundred square kilometres.

## COLUMN OF ASH

A volcano can shoot ash particles up to 40km into the air in the direction of space. They can remain in the atmosphere for years.



## CIRCLE OF DOOM

The explosion rips out a crescent-shaped area of earth.

A catastrophe is often thousands of years in the making: many volcanoes gain in strength for millennia before an immensely powerful explosion occurs. More than 1,000 kilometres of magma are bottled up in the depths until the lid of rock can no longer

withstand the pressure – and finally the first massive explosion shakes the ground. In the process more and more magma flows upwards. Gases are released which expand explosively at the surface, as the rock is no longer in place to hold them back. This process can continue for several months.

## WARNING SIGNS

An earthquake can trigger an eruption. The increasing pressure can cause the ground to rise up by several metres.



## MOMENT OF DISASTER

The gas-filled magma explodes at the surface at 1,000 degrees Celsius, like a giant, boiling bottle of champagne.

The human body is the most well-researched area in science. Yet experts have only just discovered how its powers of self-healing work. How do we beat disease? Why do tumours sometimes vanish? The answer, say researchers, lies in our brains

# HOW THE **BRAIN** HEALS THE **BODY**





### **THE ALL-POWERFUL NERVE CENTRE**

The brain controls all body processes using chemical commands. Every second, 100 billion nerve cells carrying electrical signals shoot out through neural pathways at 400km/h.

# B

Beck Weathers has less than 300 metres to go. But here, 8,300 metres up on Everest's summit, metres feel like miles. A blizzard cools the ambient air down to a chilling minus 75 degrees Celsius. Everything around Weathers is bright. The pathologist from Dallas, Texas, knows what's going on: a whiteout – like getting lost in a bottle of milk, as one climber described it. The 49-year-old has lost a glove and his right hand has become frozen and white, almost like porcelain. His nose and cheeks are black. They are signs of the next stage of necrosis that is eating through his body. "He's dead," he hears his companions say. They trek on, leaving him behind to save themselves. Weathers is in hypothermic shock due to the cold: he's conscious, but unable to even blink. It's a day, a night and another day before Weathers' brain finally regains control of his body. He starts to get up about four o'clock in the afternoon. Slowly but surely, Weathers begins to move. It's nearly 300 metres back to the camp, and it will feel like the longest journey of his life.

## Where is the brain's survival instinct found?

"Hi Ken, where should I sit?" Ken Kamler thinks a ghost has just stepped into his treatment tent. "Do you accept my health insurance?" jokes the spirit before it collapses. It's actually Weathers. The expedition doctor rushes to the apparition who, to all extents and purposes, should be long dead. He looks at the white and black-coloured body and still can't believe that this broken man has managed to survive. But, incredibly,

really not unpleasant," recalls Weathers. But something was wrong: his arm was frozen grey and sounded like wood. It dropped to the ground when he tried to lift it. "This was not bed. This was not a dream," Weathers realised. "This was real and I'm starting to think: I'm on the mountain but I don't have a clue where. If I don't get up, if I don't stand, if I don't start thinking about where I am and how to get out of there, then this is going to be over very quickly." A single thought kept him going,

**"I felt what I was doing was completely trivial compared to what he had done for himself. It shows what the power of the mind can do."**

**KEN KAMLER**, Expedition doctor

Weathers has. He lost his right arm below the elbow, all of his fingers, parts of his feet and his nose – but he made it. To date, he's probably the only person ever to survive such a situation. But how did Weathers' brain free his icy body? What really happened on 11th May 1996? Eight climbers died that day, making it one of the deadliest days ever on Everest, a drama that inspired the bestselling book *Into Thin Air*.

"There was a warm, comfortable sense of being in my bed. It was

one that he repeated over and over for hours: "I can't die, I have a family that needs me." It worked – he got up.

Expedition doctor Ken Kamler examined the apparent medical miracle by imagining what was going on in Weathers' brain: "This is what I can speculate might have been going on during this survival epic. At first, brain activity decreased to the extent that Weathers' body actually shut down. He died. Then, suddenly, more and more neurons began to fire in the centre of his brain, where the images of his family are stored. This activity then transferred to the anterior cingulate gyrus – an area many people consider to be the home of our self-determination. He started to get more energy into the frontal lobe and began to focus and

### BECK WEATHERS TRAPPED IN ICE FOR 36 HOURS

● Despite suffering from severe frostbite, Weathers still managed to save himself.



# JUST HOW POWERFUL ARE OUR THOUGHTS?

**M**ountaineer Beck Weathers should be dead. He's been in the snow for 36 hours; the ambient temperature is minus 75 degrees Celsius. His brain is barely active. But, suddenly, a small flicker of an impulse appears in his synapses. In his temporal lobe, neurons awake from their hibernation – it's the memory of his wife. His brain

summons all of its power and makes a decision: "I'm going home!" The frontal lobe in the neocortex begins an emergency analysis of all bodily functions and announces: "You have to get up immediately or you'll die!" Weathers is close to death, but he gathers all of his strength and stands up. When our brain takes control in an emergency, we can suspend and surpass the limits of our body.

## FRONTAL LOBE

In an emergency – such as an injury – this area makes sure we have the concentration to solve the problem. The brain decides which actions and movements of the body need to be adapted. Put simply, the frontal lobe takes control and decides what needs to be done for the rest of the body.

## LIMBIC SYSTEM (CINGULATE GYRUS)

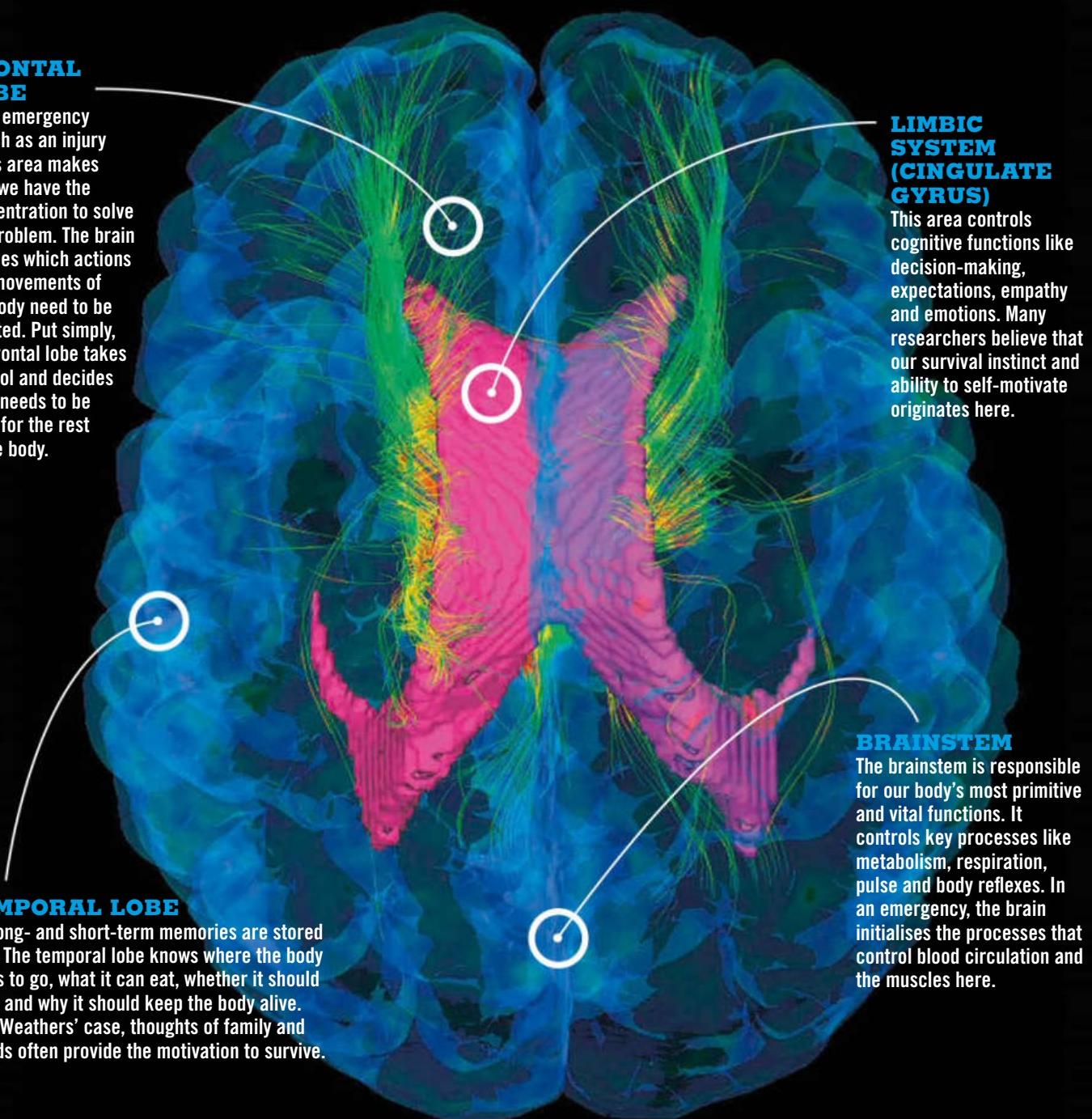
This area controls cognitive functions like decision-making, expectations, empathy and emotions. Many researchers believe that our survival instinct and ability to self-motivate originates here.

## TEMPORAL LOBE

The long- and short-term memories are stored here. The temporal lobe knows where the body needs to go, what it can eat, whether it should run – and why it should keep the body alive. As in Weathers' case, thoughts of family and friends often provide the motivation to survive.

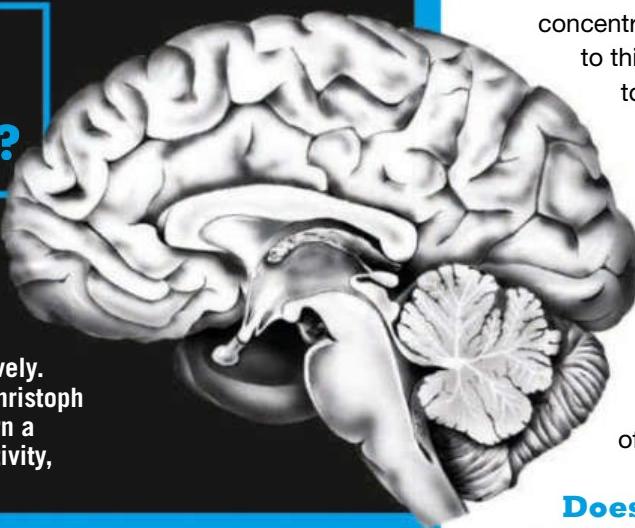
## BRAINSTEM

The brainstem is responsible for our body's most primitive and vital functions. It controls key processes like metabolism, respiration, pulse and body reflexes. In an emergency, the brain initialises the processes that control blood circulation and the muscles here.



# HOW CAN I TRAIN MY BRAIN'S HEALING POWERS?

**S**ome people are never sick, while others seem to catch every bug out there. What differentiates the former from the latter? An American study has shown that people who are relaxed and think positively are less likely to fall ill than those who are stressed or think negatively. "Psychological processes play a role," explains Christoph Bamberger, an endocrinologist. But how do you turn a pessimist into an optimist? If you're prone to negativity, outwit your feelings with the following hacks...



## 1 Get some shut-eye

● While we sleep, our body can repair up to 50 billion damaged cells – per second. And this cell-maintenance acts like a rejuvenation program – not only for the body, but also for the mind. Most challenges are much easier when you're well rested and recovered. Positive thoughts are a natural side effect of getting a good night's rest.

## 2 Be an upright citizen

● Our posture has a direct effect on how we feel. A slumped body not only reflects negative thoughts – it also produces them. Researchers in New Zealand studied the effect of posture on mood. "The upright participants reported feeling more enthusiastic, excited and strong, while the slumped participants felt fearful, hostile and sluggish," said the study's authors.

## 3 Take time to laugh

● When you laugh, you activate muscles that stimulate the brain to release chemical messengers like serotonin that induce feelings of satisfaction. Psychologist Fritz Strack showed that smiling works just as well. Study participants held a pencil in their teeth (which activates the muscles typically used for smiling) or lips (which does not activate those muscles). Those who were 'smiling' were more cheerful than the people who weren't. The brain doesn't care why you're smiling – just that you do it.

## 4 Don't be a victim

● Some people see themselves as victims of fate, totally at its mercy – and feel like they have no control over their lives. It helps to adopt a perspective that puts into focus what you can make of a particular situation – despite life's adversities. Avoid phrases like "I wish I had..." or "if only I could..." – and look to the future. If you ask yourself "what can I do today to make my life better?" every morning, you'll train yourself to automatically have positive thoughts.

## 5 Do the downward dog

● For centuries, one technique has been used to stimulate the connection between the brain and the body: yoga. The distinctive poses harness the power of thought and even have positive benefits at a cellular level. Canadian researchers demonstrated this in an experiment at the University of Calgary. Breast cancer survivors who practised mindfulness-based meditation and Hatha yoga every day for eight weeks had healthier telomeres than those that did not. Telomeres are the protective protein strips at the end of chromosomes. Longer telomeres protect against disease. Using yoga, subjects managed to manipulate the structure of their DNA so that they aged more slowly than those in the control group. Scientists now say that yoga may even act in ways similar to antidepressants and psychotherapy, making it a viable treatment for depression.

## 6 Strain your brain

● Neurologists use a technique known as 'neurofeedback' to strengthen the psyche. The technique is aimed directly at the brain's thought processes. As the name suggests, neurofeedback works by providing feedback to an individual about their brain, specifically, their brainwaves. This is achieved by attaching electrodes to the subject's head and measuring the resulting brainwaves, which are relayed to a computer and shown on a screen. Feedback in a vacuum, however, is useless, so the individual undergoing neurofeedback is rewarded for patterns of brainwave activity that are better for the person. This is referred to as "self-regulation," because the individual is learning how to regulate their own actual brainwave patterns on their own, without medications or additional therapy.

concentrate. Weathers started to think 'what can I do to save myself?' His lungs started to work faster and his muscles tensed. What I could do for this mountain climber as a doctor was insignificant compared to what his power of thought achieved."

## Does the body have a self-repair mode?

Did Weathers just get lucky? Jerome Groopman, a doctor at Harvard University, thinks otherwise: "Thoughts and emotions are often seen as secondary in medicine. In truth, they're nothing more than a mixture of chemicals and electrical impulses in the brain." This means that everything we think isn't down to some metaphysical abstraction, but is instead a process between cells. It's an integral part of our bodies, measurable and verifiable.

It may seem like our brain has nothing to do with maintaining the body. But wounds don't heal themselves and the body doesn't kill germs or renew cells entirely on its own. In reality, there's a direct link between the body and the brain – and a certain way of thinking may well have a physical effect. Whether it's anxiety, sadness or joy, a certain mindset unleashes specific biochemical reactions in the body. This is because the body doesn't react well to being put in a stressful situation and enters a state of emergency within a few seconds – the pupils dilate, heart rate and blood pressure skyrocket, the vascular system is flooded with stress hormones and digestion shuts down. Scientists accept that not enough research has been carried out on whether the body is only able to repair itself when it's

## **BEATING CANCER**

# **How do thoughts work against cancer cells?**

● Research has shown that people recover more quickly from colds when they think positively. But what about more serious illnesses like cancer, Aids or paraplegia? Ultimately, very little serious research has been conducted in this area, but more than 1,000 cases involving the spontaneous remission of illnesses deemed incurable have now been scientifically recognised. This came as no surprise to those doctors who have been promoting the self-healing capabilities of the human brain.



## **KILLER COMMANDO**

Cancer cells have to camouflage themselves; otherwise they'd have no chance against the immune system. In this image, macrophages (white blood cells) are destroying undesirable foreign cells.

relaxed. "Changing our thoughts might actually affect the way in which the brain communicates with the rest of the body," says cell biologist Bruce Lipton. "If we change the mental interpretation of a disease so that a positive expectation takes the place of fear, it triggers a biochemical reaction in the brain that affects the composition of the blood. And that causes cell alteration on a biological level."

### **Can thoughts heal me?**

There are thousands of examples of how PAIs (Positive Activity

Interventions, a positive thinking method) affect bodily processes – even when drugs and surgery fail. A trial at the University of Georgia showed that 15 minutes of meditation a day reduces chronic hypertension. Liege University Hospital in Belgium conducts some operations under hypnosis instead of general anaesthetic. A study at the University of Manchester showed that autogenic training (a form of relaxation therapy that teaches your body to respond to verbal cues) cures headaches. The patients of US cardiologist Dean Ornish, meanwhile, can

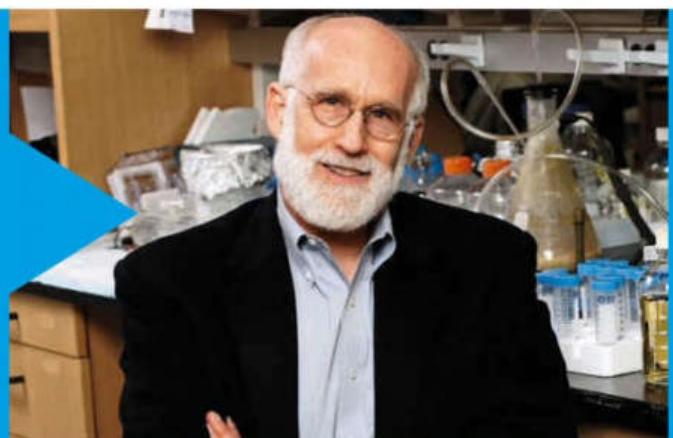
unblock clogged arteries using visualisation methods alone.

The relationship between a positive mental attitude and physical health was made clear by the pioneering Grant Study. Researchers at Harvard Medical School assembled a group of students, all of whom were prime examples of physical fitness and mental health. The aim was to observe how criteria like health, happiness and relationships affected their lives. The researchers found that pessimistic subjects, once aged 45, were no longer as healthy as the optimists. Disease

&gt;

**"A change in mindset has the power to alter neurochemistry."**

**JEROME GROOPMAN**, oncologist





#### PAIN CAUSED BY OUR THOUGHTS

## How does my brain heal back pain?

● Slipped disc? Sciatica? Or is it all in the mind? In a controversial new book, physiotherapist Nick Sinfield argues that chronic back pain is frequently caused by underlying emotional tension. A gradual accumulation of stress and anxiety over several months, or years, can lead to changes in the muscles, nerves and ligaments surrounding the spine – causing them to tighten and cutting off the blood supply to the back. This results in pain, which is often agonising. "Emotional stress expresses itself in painful physical tension – most commonly in the soft tissues in the neck, the top of the shoulders and shoulder blade, the lower back and the outside of the buttocks," says Sinfield. But this process can be reversed. If back pain is mainly in our heads, meditation and yoga techniques can train the brain over time to be less stressed and, therefore, feel less pain.

**"The mind has the power to heal our bodies."**

**CHRISTIANE NORTHRUP,**  
wellness expert

manifested itself earlier in the negative subjects and took a more severe form. Those who had a positive outlook on life were 45% less likely to die from any cause than those with a negative view – and had a 77% lower risk of dying from heart disease. In another study at Miami University, elderly people were found to live seven years longer on average if their perceptions about ageing were positive. Optimists are more likely to survive chronic illnesses like cancer and to have healthier immune systems.

#### How do placebos affect the brain?

Positive thoughts sometimes accomplish the impossible: we've all heard instances of paraplegics walking again and malignant tumours suddenly regressing. Doctors call it spontaneous remission – patients call it a miracle. It occurs in just one in 100,000 cancer cases. The cause remains a mystery – though it's definitely not a miracle, but a bodily process. "The mind has the power to heal," says Christiane Northrup, an expert on the mind-body connection. "Fear increases cortisol and epinephrine in the body, which over time lower immunity. Hope is a biochemical reaction in the body," she says.

But what use is this knowledge to individuals? Does everyone have the ability to manage their health or is it only for very determined people? There are a few tricks: the use of placebos, for example, can



CARDIOLOGIST DEAN ORNISH

## Can images protect me from a heart attack?

● American cardiologist Dean Ornish asks his patients to picture the inside of their bodies and visualise their organs working at peak capacity. Simultaneous CT scans showed that clogged arteries can be reopened using the power of these images alone. And Ornish's mental training effectuates something else: the heart is able to produce new cells and rebuild itself.

be a popular way of harnessing our inner healing power.

One study prescribed placebo drugs to patients, who were told they were being given an 8mg dose of morphine. But the sugar pills still had an effect, even once the patients found out they'd taken a placebo. "For my patients, hope, true hope, has proved as important as any medication I might prescribe or any procedure I might perform," explains Jerome Groopman. He's found that the brain produces chemicals that can facilitate healing. "Belief and expectation – the key elements of hope – can block pain by releasing the brain's endorphins, mimicking the effects of morphine. In some cases, hope can also have important effects on fundamental physiological processes like respiration, circulation and motor function," he says. Which might explain the apparently miraculous cases of spontaneous remissions.

But why are the healing functions of our body so difficult to activate in

**"Your thoughts and perceptions have a direct and overwhelmingly significant effect on cells."**

**BRUCE LIPTON**, cell biologist

stressful situations? If the ability to heal were anchored in the brain, it would be more easily accessible, but perhaps we've simply forgotten how to access it. As medicine has advanced, we've come to rely on drugs. The powers of our own bodies have been neglected – similar to skills we used and needed as cavemen, but no longer use and have allowed to waste away.

Another set of studies showed how you perceive yourself affects your health. Researchers at Yale

University found that people who had positive perceptions about ageing were less likely to have a heart attack or stroke as they grew older. Beck Weathers is the best example of the power of positive thinking. He felt completely transformed by his Everest ordeal: "Four months after they cut my hands off, I went back to work. For the first time in my life, I have peace. I no longer seek to define myself externally, I live each day as if it's my last, and it's an exquisite pleasure." ■

# TECHNOLOGY



## ►INVASION

High-tech drones are used by a number of military forces, but simpler models are freely available to buy online, in electronics stores and even in toyshops. \$200 will buy you a basic quadcopter with live video streaming.





They monitor rail tracks in France, wind turbines in Germany and climate change in the Antarctic. But drones are also being used for more sinister purposes, flying into restricted airspace over nuclear power plants, military installations and airports. Now, to combat their growing threat, new anti-drone technology has been developed. Let the battle for the skies commence

# DRONE VS. DRONE



# HOW DO THE NEW ANTI-DRONE SYSTEMS WORK?

● Security experts are sounding the alarm: more and more private drones are trespassing over highly sensitive areas. In autumn 2014, drones breached restricted airspace over 13 of France's 19 nuclear power stations, while last July a drone came within six metres of an Airbus A320 landing at Heathrow, UK. French authorities are now fighting fire with fire with their new 'anti-drone' Rapere defence system, which is being used by many of the country's nuclear power station operators. When a hostile drone enters restricted

airspace, a Rapere drone is scrambled to intercept it. It neutralises the threat by dropping metal tangle lines into the hostile drone's rotor blades. Meanwhile, China has been testing laser defence systems in its battle against unwelcome visitors. These work by shooting down drones and are effective at heights of up to 500 metres. Then there are hacker drones – special drones with on-board software that detects other drones' signals. Once the system locates a hostile drone, the hacker takes control of it and forces it to crash.

1

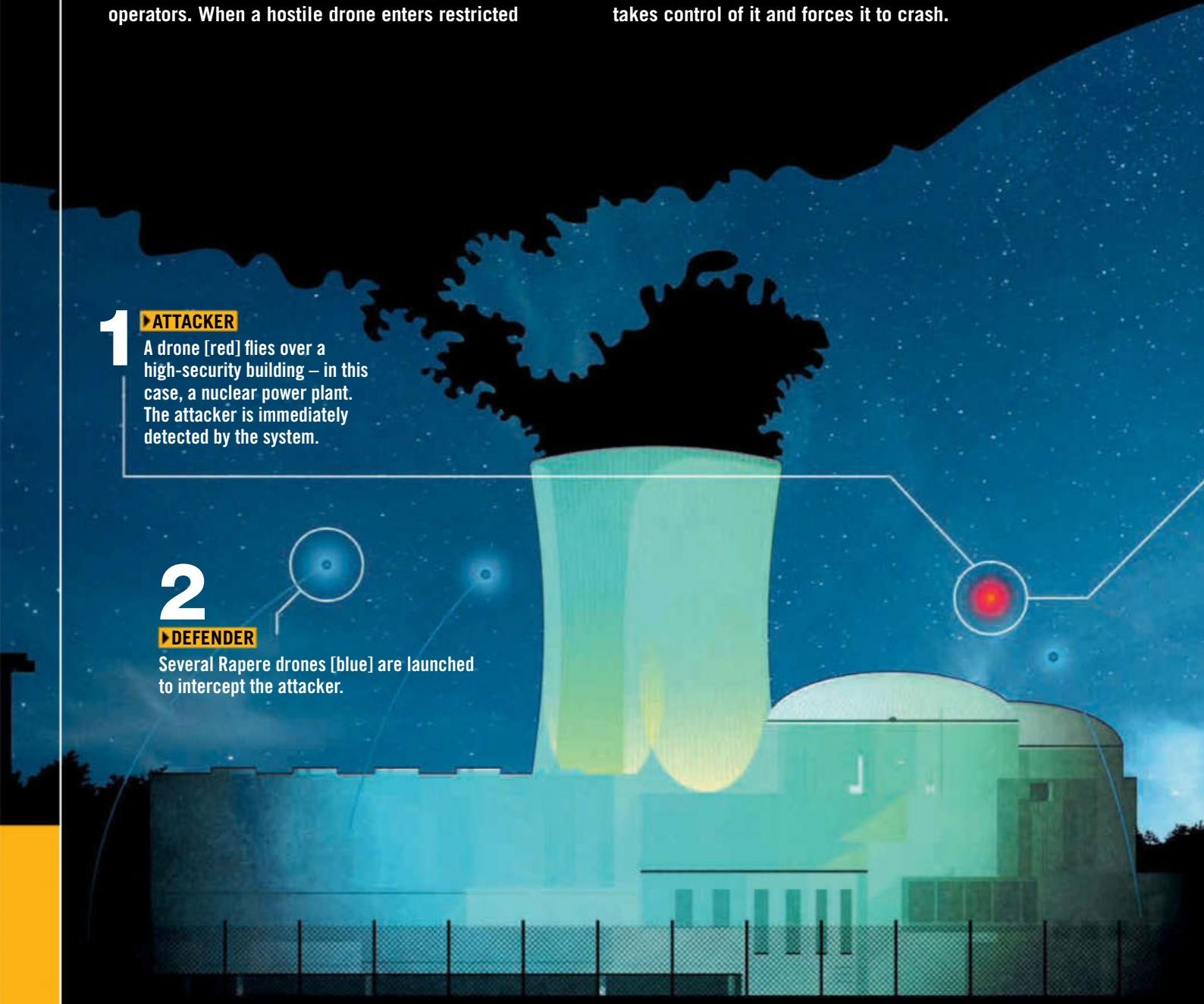
## ATTACKER

A drone [red] flies over a high-security building – in this case, a nuclear power plant. The attacker is immediately detected by the system.

2

## DEFENDER

Several Rapere drones [blue] are launched to intercept the attacker.





**WHEN DRONES ATTACK\***  
Use the free viewa app and scan  
this page to see terrifying footage  
of US drones targeting ISIS

# 3

## ►ELIMINATION

30 seconds after the attacker enters restricted airspace, it has been neutralised by the Rapere drone [right]. Two more anti-drone systems have been tested in China and Germany.



### 1. Rapere system

Hanging just above the attacker, the Rapere drone releases its metal tangle lines.

The lines tangle in the rotor, causing the attacker to crash



### 2. Laser system

This Chinese system uses a mounted laser with a mile-long range. Attackers are shot down just five seconds after being spotted.



### 3. Hacker drone

Using programs like SkyJack, the operator can forcibly disconnect a hostile drone from its wireless network and add it to his or her own – and then control the hijacked drone.



MILITARY



PRIVATE



DUAL PURPOSE



RESEARCH

## Number of drone types

### ►THE CONQUEST OF THE SKY

There are currently more types of military drone in operation than there are commercial ones. But US authorities predict a huge increase in private numbers over the next five years.

**T**he lowlifes are going to get the shock of their lives later, because tonight's the night that François Durant\* and his colleagues strike back. Durant sits behind a bank of surveillance monitors at the Civaux nuclear power plant in Poitou-Charentes, France, concentrating intently on the one showing its airspace...

For six weeks now, drones have been flying over the power plant, either late at night or early in the morning. Usually they arrive solo, but two weeks ago four suddenly turned up at once. Infuriatingly, the drones vanish just as quickly as they appear, meaning local police and plant security have no chance to track where they're coming from. But, as of today, the Civaux plant is no longer at the mercy of these invaders. At long last Durant's team

can defend themselves. Because today is the day the Rapere shield comes into service.

Suddenly, a piercing alarm sounds in the command centre. "Four drones approaching the nuclear reactor! Three o'clock!" shouts Durant to his security chief. "Okay, let's get started," he answers. Durant hits a button and moments later five defensive drones shoot out from their well-concealed launch pads in the power station. They hurtle towards the attack drones – completely autonomously, without a pilot controlling them. Thirty seconds later and the Rapere intercept drones have positioned themselves above the hostile attackers. Then they release their cargo – metal 'tangle lines' that snare themselves in the attacking drones' rotor blades and cause them to crash.

### CAN A HOBBY DRONE MAKE A PLANE CRASH?

Although the series of drone attacks on French nuclear power

plants at the end of 2014 didn't cause any damage, they were still treated as a serious offence by the authorities. In fact, the French government classified them as

**"The risk of a small drone being ingested into an airline engine is very real."**

JIM WILLIAMS, DRONE SPECIALIST



criminal behaviour and a terrorist activity. No wonder: a scenario in which drones are equipped with explosives and then crashed into a nuclear power plant has long been considered a realistic threat. Any such attack could cause untold damage.

As previously reported in *World of Knowledge*, drones are widely available to buy on the internet. One such is the HT-8 C180, capable of carrying a load of 2.5kg at a maximum speed of 55km/h. Flight time? Around 20 minutes with a full load, ample time to cause some mischief. But you don't need explosives to cause a catastrophe with a drone.

Aviation experts have long warned against the life-threatening consequences of hobby drone pilots meddling with air traffic. The UK's House of Lords EU Committee recently called for the compulsory registration of all drones –commercial and civilian – amid growing concern over the use of drones by people with little knowledge of aviation rules. Last July a drone came within six

#### ►CAUGHT

French security experts have developed a new drone-catching system that involves the attacker being trapped in a net.



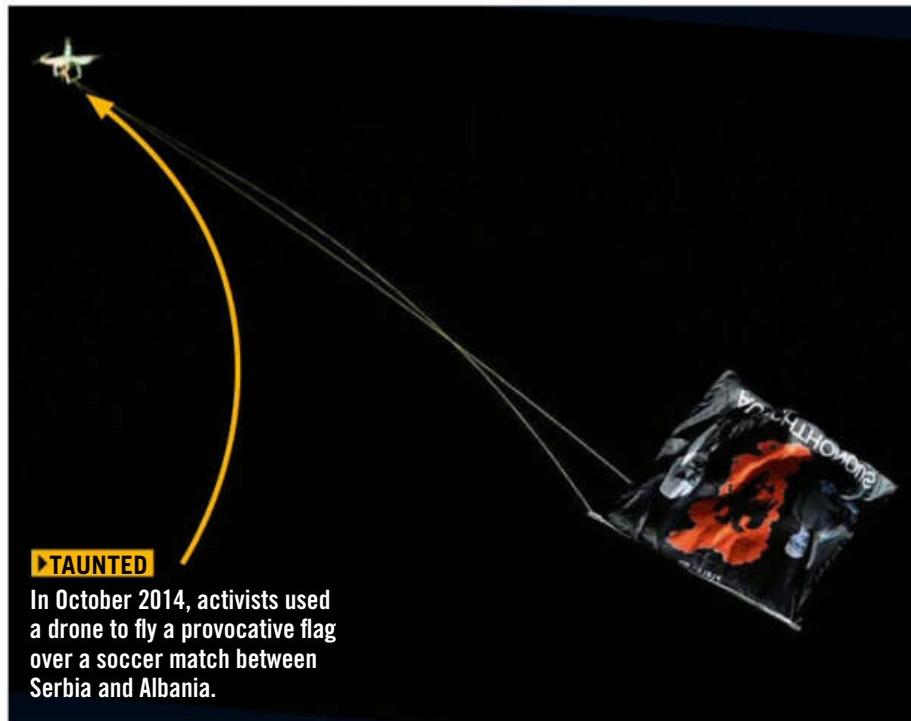
\*NAME HAS BEEN CHANGED



metres of a plane landing at Heathrow, UK, and the pilots' union BALPA has warned that drones pose a real threat to aircraft. Drone specialist Jim Williams from the US Federal Aviation Administration (FAA) recalls an incident in Florida that almost caused a plane to crash: "The drone was flying just a few metres over the passenger jet and it would've ended in disaster, if the drone pilot wanted it to." A drone can cause particular damage to the engines by steering into the plane's air ducts. "The risk of a small drone being ingested into a passenger airline engine is very real," Williams says. "The results could be catastrophic." Last year, the FAA registered more than 175 documented sightings of drones near American airports and nearly 30 close-shaves involving drones and passenger jets. This year the figures are expected to rise.

### WHEN WILL THE FIRST ASSASSINATION BY DRONE TAKE PLACE?

Last year a drone carrying a flag emblazoned with the insignia of 'Greater Albania' was flown into the middle of a soccer match between Serbia and Albania, sparking a mass onfield brawl. Now Chief Inspector Nick Aldworth of London's Metropolitan Police has expressed concern over drones being used to promote similar civil unrest in the UK. Politicians have also started to become targets. A 40cm-long



drone suddenly appeared at a campaign rally for Angela Merkel last year, crashing to the ground just a few feet from the German chancellor. Luckily, the drone wasn't found to be carrying anything harmful, but security forces were alarmed. According to German investigators, the deliberate steering of drones armed with explosives into passenger planes or airports is a plausible scenario. They think attacks on targets in populated areas, crowds of people and buildings are also conceivable.

Aldworth too is worried. "We know this technology has been used to embarrass people," he told a recent House of Lords enquiry into drones. "One of these devices was dropped at the feet of Angela Merkel. Could we see that sort of protest or disruption elsewhere? It is certainly one of the areas we are looking at."

France has become the first country in Europe to take the fight to the drones. Its National

Research Agency has been commissioned to develop ways to both identify and intercept drones. In the meantime, there's the prototype Rapere system. Named after the Latin for 'destroy', Rapere is an 'anti-drone' drone that's fitted with 12 high-resolution cameras. Launched at the touch of a button, the drone scans the sky looking for the motion of another object – though the makers assure us it can distinguish between drones and birds. They're also confident that Rapere is faster and more agile than any type of commercially available hobby drone.

### ARE THERE DRONES THAT CAN INTERCEPT OTHERS?

Rapere's flights will be more like quick sprints – the makers claim their drone will identify a target, attack, and return to a charging station all within a two-minute flight span. They won't divulge its top speed, but its pace and incredible manoeuvrability have been achieved by drastically reducing >

# HOW DOES A DRONE WORK?

The more complicated the drone, the more high-tech equipment it has. It's the interaction between its steering software, camera, rotors and many other components that gets the drone airborne, makes it manoeuvrable and

allows it to film. At the heart of every drone is its processor, in this case a Pixhawk PX4 Autopilot [centre]. It costs around \$300 and serves as an interface for the individual components.

## ► ROTORS

Quadcopter drones maintain their balance and lift using four rotors. The processor controls them.



## ► BATTERY

The lithium-ion polymer battery supplies the drone with energy. A quadcopter can stay airborne for up to 40 minutes between charges.

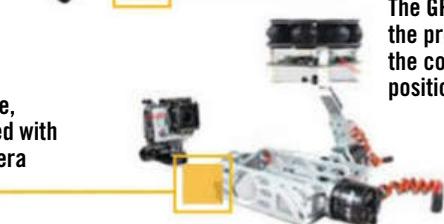
## ► TABLET

A connection is made between the processor and a tablet or PC using a telemetry transmitter.



## ► CAMERA

Depending on their size, drones can be equipped with a high-resolution camera such as a GoPro.



## ► SPEED CONTROL

The processor controls the speed of each rotor separately using the ESC (Electronic Speed Control) unit.

## ► BUZZER

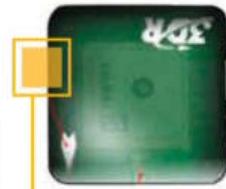
Using acoustic tones, the buzzer keeps the pilot informed as to the drone's status.

## ► RECEIVER

The receiver is connected to the processor and transfers the transmitter's commands.

## ► GPS TRANSMITTER

The GPS is connected to the processor, ensuring the control and positioning of the drone.



## ► TRANSMITTER

Drones can't be controlled by tablets alone. You'll need a remote-control transmitter.

the drone's weight. This came at the expense of the flight time, though experts think that 120 seconds is still ample time to bring down an enemy. Rapere does this using a simple method that's anything but high-tech: it hovers above an attacker and drops a metal 'tangle line' that gets caught in the rotors, causing the drone to crash. After its day's work, Rapere returns to base and is recharged.

China employs a more brute-force method than France – a group of companies has developed a powerful anti-drone laser that can zap drones up to two kilometres away. Led by the China Academy of Engineering Physics, and collaborators like China Jiuyuan Hi-Tech Equipment Corporation, the consortium is convinced of its system's effectiveness.

"Intercepting drones is usually the work of snipers and helicopters, but their success rate is not as high and mistakes with accuracy can result in unwanted damage," explains Yi Jin-Song, a manager at Jiuyuan. The laser system – the actual project name is unknown – gets rid of this uncertainty. Using electro-optical sensors for targeting, it takes about five seconds to compute a firing solution and can take down drones flying at an altitude of up to 500 metres at speeds up to 160km/h. More than 30 drones were shot down in a recent single test run. The success rate? 100%.

## HOW DO I PROTECT MYSELF FROM DRONES?

As well as anti-drone drones, there's also a growing market for drone recognition systems like DroneTracker. Using audible and visual sensors, this system alerts the user whenever a drone strays within 100 metres of its sensors.

# ARE DRONES THE NEW DRUG MULES?

They're small, cheap and don't talk – perhaps that's why Mexican cartels have been using drones to smuggle drugs over the US border for the past four years. During this time authorities have managed to down 150 of the UAVs, recovering more than two tons of cocaine in the process. The number of successful flights was probably much higher.

The sneaking of contraband into prison using drones is a big problem elsewhere in the world, too. In March this year, a drone crashed into barbed wire on the perimeter wall of Bedford Prison in the UK. Its cargo? Drugs, a knife, a screwdriver and mobile phones. Similar stories have emerged from Brazil, Greece, Russia and Ireland.

By using several DroneTrackers together, the monitored area can also be extended. The manufacturer claims it offers protection against "spying, smuggling, potential terrorist attacks and invasions of personal privacy." They envisage it being used in government buildings, prisons, sports arenas and airports, and suggest it could also offer protection in and around sensitive construction sites. The monitored airspace can be viewed in real time

drones can use Cyborg Unplug. This is a modified wireless router that monitors the air for wireless signatures from devices you don't want around – like drones.

Identifying and deactivating drones aside, there's another method of fending off drones: hacking them. In December 2013, American hacker Samy Kamkar demonstrated his SkyJack project. Kamkar succeeded in hijacking a Parrot AR drone, a cheap model loved by hobby pilots, using another drone. To accomplish this, Kamkar fitted his own quadcopter with a Raspberry Pi mini-computer and various wireless transmitters. Software recognised the signals of other drones nearby. How? Because every drone possesses its own individual MAC address, like any other network-compatible device. SkyJack is, therefore, able to identify a drone by its network, throw them off it, and authenticate in its place, taking it under control.

Lasers, hacker attacks, drone kidnappings – what all these anti-drone methods prove is this: the war above our heads has only just begun. **W**

You can't only hack drones – you can also kidnap them and **make them into zombies!**



SAMY KAMKAR, DRONE SPECIALIST

on a smartphone, and the user is notified when a threat is detected.

Meanwhile, people who want to protect their own houses from

# THE INCREDIBLE INTELLIGENCE OF CROWS

They are some of the smartest animals in the world: crows are master toolmakers, use cars to crack nuts and even give dogs the runaround. But these clever birds also shine in another area: they understand humans!



# DO CROWS MAKE FRIENDS?

# Crows are extremely empathetic animals and often express their thanks for food by offering small gifts. For the past four years, eight-year-old Gabi Mann from Seattle has been showered with gifts of buttons, stones and screws, some of which are pictured here. There are many examples of this kind of unusual human-animal relationship. Fellow American Lynn Witte raised an injured infant crow by hand and nursed it back to health. When she had learned to fly, 'Sheryl Crow' would regularly bring back gifts from her trips.



# A

crow lies in wait on the lawn of a garden in the small town of Pfaffing in Germany. Suddenly it strides forward, snapping at a bunch of desiccated leaves, ripping them into pieces, stamping around on them and then cawing loudly, before going back to snatch more leaves. The same thing, over and

over again. And this isn't the first time the bird has acted this way. It's been visiting Jo Muller's garden for years. And all this time she has been feeding her black, feathery visitor breadcrumbs and cat food. If there's one thing you need to know: cat food is one of the crow's favourite dishes.

But what is the bird aiming to achieve with its curious behaviour? Why is it tearing leaves into pieces and trampling on them? Is the food that Edna leaves out not sufficient? Quite the opposite: Jacob, as Muller has named the bird, wants to show his gratitude – and that's why he's helping with the gardening. But how does Jacob know what to do? "He spent a long time observing me," says Edna. "He understood that

I don't like dried, dead leaves and that's why he always plucks them from my plants. He copied me. Some days he is so driven he works faster than a shredder." And Jacob is by no means the exception. Countless studies have revealed the same thing: the birds of the *Corvus* genus, which also includes magpies, jays, jackdaws and ravens, have been watching us humans for a very long time.

## CAN CROWS TAKE PITY ON ABANDONED PETS?

That means that they recognise when we need help: many crows fed by humans bring their benefactors presents, such as stones, marbles or buttons. The



GABI MANN,  
AGED 8, FROM SEATTLE

## HOW DO CROWS THANK US FOR A FEW CASHEW NUTS?

Gabi Mann has been feeding crows and pigeons in her garden for years. To show their gratitude the crows leave behind all manner of presents in the feeding tray: feathers, pieces of glass, screws, buttons, Lego bricks, hinges and more. "The fascinating thing about this story is that crows and humans understand each other. The birds know that we are presenting them with

a gift when we leave out food for them," says wildlife expert John Marzluff, "and so a genuine friendship can develop." Gabi's mother also appreciates the crows' gestures: one day she lost the lens cap from her camera. Later that day it appeared on the edge of the birdbath – footage from the bird-cam placed there showed the crows cleaning it in their water trough before returning it.

birds appear particularly grateful when they have been injured and humans nurse them back to health. But where has this unique behaviour, the like of which no other animals display, come from?

"We believe that crows' social intelligence, which is similar to ours, has played an important role in their development. It has made the birds an absolute model of success," says Professor Thomas Bugnyar, a corvid expert based in Vienna.

Corvids are team players: they flock together to chase off enemies like eagles. They warn one another of dangers such as people throwing stones at them. They also feed and care for injured comrades. In 1999, a crow in Massachusetts, USA, took an abandoned kitten under its wing and cared for it by feeding it insects – the two were inseparable for five years. It's this trait that makes crows special: they feel empathy. They are able to put themselves in other animals' shoes.

## ARE CROWS AS INTELLIGENT AS CHILDREN?

"Our observations even lead us to believe that crows forge alliances, intervene to settle conflicts between members of their own species and comfort one another," says Bugnyar. "Previously we'd only seen these abilities in primates."

## CROWS MAKE FRIENDS, CARE FOR THE INJURED AND SETTLE CONFLICTS

### CLEVER COLLECTORS

As well as being able to use rudimentary tools, crows also know how to endear themselves to humans.



Scans reveal the brains of crows are very large in relation to their bodies. "Their brains are much more complex than previously believed, with highly specialised regions," explains Dr John Marzluff, a socio-ecologist at the University of Washington. "They function in a similar way to the human brain. Crows can reflect on the information they take in. They think mindfully, instead of behaving on instinct. That means they even make plans – for example, when considering how they can retrieve food from a long, narrow glass. The different halves of their brains are capable of working separately from one another, unlike ours, so they can even reflect while they're sleeping. Brain scans also suggest that crows can dream."

Crows are on the same intellectual level as chimpanzees, which makes them about as intelligent as a seven-year-old child. Scientists came to this conclusion after subjecting six wild New Caledonian crows to a number of tests designed to challenge their understanding of cause and effect. In one experiment, a thirsty crow would drop stones

into water-filled tubes to raise the level of liquid in the pitcher.

These masterminds of the animal kingdom can even differentiate between human faces. "As they have an unbelievably good memory, they never forget a face and always recognise people they've seen before. Crows are much more intelligent than most people assume," says Marzluff.

Crows even have a command of words and can speak whole sentences. Thanks to their incredible powers of imitation, they can replicate sounds exactly. "Some crows make and use tools, forecast future events, understand what other animals know, and – in some cases – learn from individual experience by observing parents and peers. These are all advanced cognitive tasks shown by only a few animals," says Marzluff.

"They're keen to try everything out because of their extreme curiosity and ambition, and that makes them pretty inventive. They can solve any problem and build up an enormous knowledge bank over the years – and then they share that with their flock and pass it down to their offspring." W

# LEAD WHO S



**VOICES OF AUTHORITY**  
Divided by continents and  
wildly different as people,  
but they all had one thing in  
common: the ability to lead.

# LEADERS SHAPED THE WORLD



The finest leaders all have something in common. As shown by these exclusive excerpts from the new book *50 Leaders Who Changed History*, what separates the great from the good is the ability to motivate others, make difficult decisions and articulate a compelling vision.

**H**istory has been shaped by a host of inspirational leaders, from bold military strategists like Napoleon Bonaparte and great social reformers like Nelson Mandela, to innovative free thinkers like William Shakespeare and driven empire builders like Queen Victoria. Men and women of moral character, energy, self-discipline and bravery, linked by their ability to connect with and inspire those that they led. But what sets a great leader apart from the masses? Should they be combative or compassionate? Is being a visionary and a risk-taker better than leading by committee and taking on board the views of others? Can a leader get by on charisma and force of personality alone? The examples of the six leaders featured here demonstrate the varied leadership styles that have been successfully developed and adopted. Drawn from the fields of society, politics, religion, technology and the military, each of our six leaders determined their own style, ideals and aims but all had one thing in common: a profound belief in what they were doing, and a steadfast conviction to their cause.

# GENGHIS KHAN

Fearsome Mongol chief who used military might to build a vast empire

1162-1227

To work a team effectively, leaders need an ability to listen. Genghis Khan, famous for his bloody waging of war, might not seem an obvious example of this, but he was also open to advice and willing to learn.

For example, he heeded his advisors when they suggested he preserve the villages and craftsmen of the territories he conquered. By doing this, they argued, he could levy taxes on their produce over the years. Khan was persuaded to take the long view.

In war, though, Khan was utterly merciless. Showing the ruthless ambition that was to become his trademark, Khan defeated all his rivals to become sole leader of the Mongols in 1206 and went on to build one of the largest empires in history. Never one to dream small, his initial target was China. In 1211 he launched a full-scale onslaught and four years later captured Beijing. Between 1219 and 1223 Khan overran the Muslim empire of

**LEADERSHIP  
QUALITIES**  
**DISCIPLINED**  
**RUTHLESS**  
**DETERMINED**

Khwarezm in Central Asia and Persia, massacring the population. Local communities were subjected to untold horrors. One account details how Inalchuq, governor of the city of Otrar (now a ruin in Kazakhstan), was captured by Khan and sentenced to death through the pouring of molten silver into his eyes and ears.

As vividly demonstrated by such an episode, Khan was known for punishing every slight against him and never letting an enemy or subordinate feel they had the upper hand. He demanded total loyalty by ruling with an iron fist. But he also built loyalty through other

## TIMELINE

**1162**  
Born near Lake Baikal, Mongolia

**c1171**  
Abandoned by his tribe

**c1176**  
Kills his half-brother Behter

**1178**  
Maries Börte of the Onggirat tribe

**1184**  
Rescues Börte from the Merkits

**1190**  
Unites Mongol tribes

**1206**  
Sole ruler of Mongols after defeat of rivals

**1211**  
Launches all-out assault on Jin dynasty



means. On occasion he was open to being merciful and promoting brave enemies to serve in his army. One such foe, a man named Zurgadai, was given a position even after shooting Khan in the neck with an arrow. Zurgadai would later become one of the Mongols' foremost generals and one of Khan's most loyal subordinates.

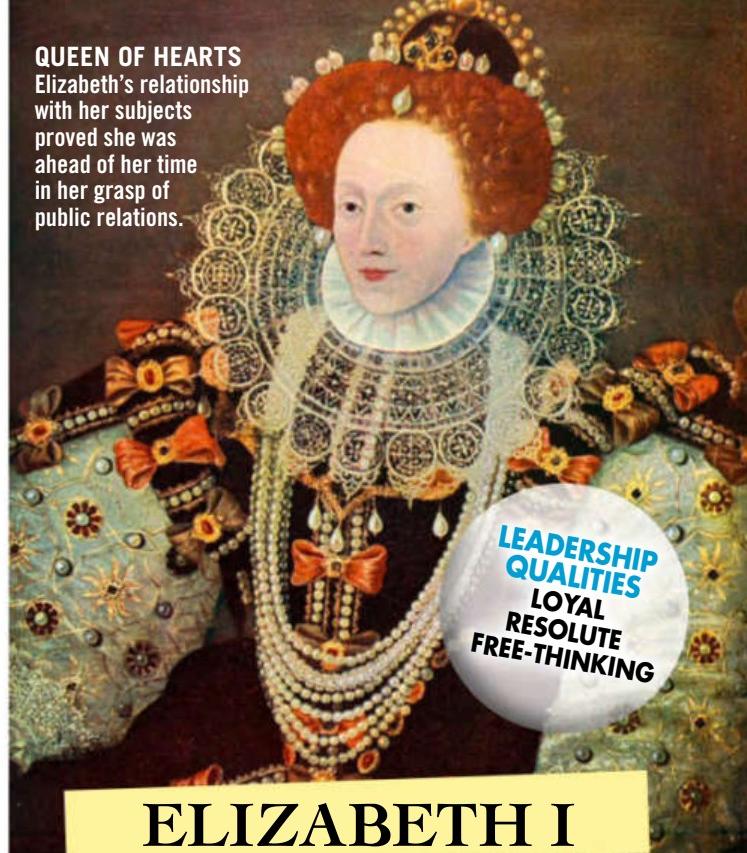
Khan's reputation travelled before him. Enemies could be reduced to a state of abject terror before any fighting began. Quick surrenders were commonplace. He was brutal too – after he overwhelmed the Tatar tribe in battle, he slaughtered every survivor who was taller than the axle of a cart. His thinking? Anyone shorter would have been a child of impressionable age who would grow up in thrall of him.

For such a fearsome man, Khan was remarkably tolerant when it came to religious faith. He was a follower of the Mongols' shamanistic religion that honoured spirits of mountains, winds and sky, but he allowed the peoples in his territories to follow their own faith freely – be they Christian, Buddhist, Muslim or Taoist. Though generally considered the epitome of a cruel warlord (estimates of the number of people

who died under his watch range from 10-25% of the world's population at the time), Khan united disparate tribes, advanced learning in society and in some senses ran his vast kingdom in a meritocratic way. No mean feat for an empire that, at its peak, spanned 33 million square kilometres.



**QUEEN OF HEARTS**  
Elizabeth's relationship with her subjects proved she was ahead of her time in her grasp of public relations.



## ELIZABETH I

Proud Tudor who made herself the icon of a nation

1533 - 1603

Quick-witted and intelligent, Elizabeth I led her country in a period of history dominated by men – one in which the legitimacy of a female ruler was questioned by many. When she took the throne in 1558, England found itself divided by religious conflict, prone to battles of succession and vulnerable to the great European powers of France and Spain.

It's her status as the 'Virgin Queen' that makes Elizabeth such a remarkable leader. Instead of wedding a foreign prince, she chose to dedicate her life to her country – and its people. A marriage to a foreign ruler would have involved England in another country's affairs; wedding an Englishman might have sparked conflict among noble factions. Elizabeth is a powerful example of how a leader can benefit from controlling the terms on which she engages with her role and her followers.

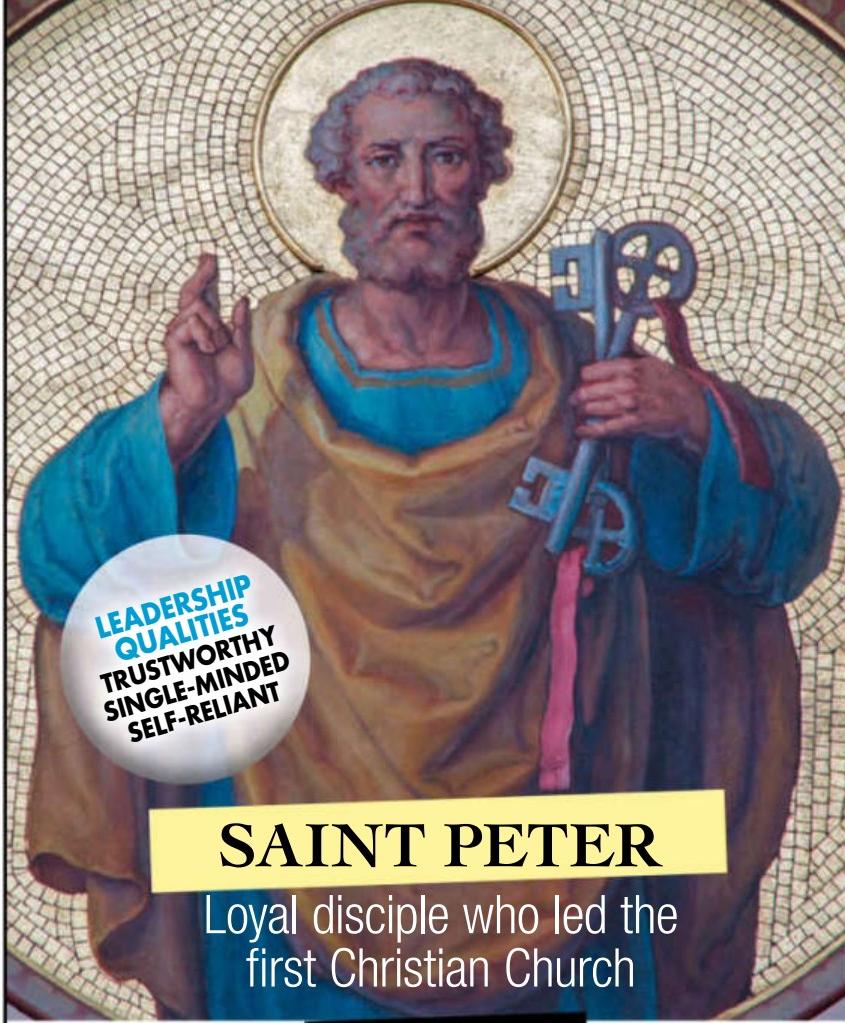
Elizabeth oversaw a golden age that included the defeat of the Spanish Armada and daring voyages of discovery. She was a devoted patron of the arts: poetry, theatre, music and art saw a remarkable renaissance under her reign. England's economy flourished and the country became a prosperous place to live.

Her stirring words to the troops massed at Tilbury in 1588 led one onlooker, James Aske, to describe Elizabeth as a "sacred general". Knowing the Spanish Armada was en route, she delivered the immortal lines, "I may have the body of a weak and feeble woman, but I have the heart and stomach of a king, and of a king of England too." These words are forever associated with Elizabeth as an inspirational leader and a fiercely loyal protector of her people.

**1215**  
Captures Jin capital Zhongdu (Beijing)

**1219-23**  
Overruns Muslim empire of Khwarezm

**1227**  
Dies



## SAINT PETER

Loyal disciple who led the first Christian Church

1BC-64AD

**F**oremost among his followers, Peter was chosen by Jesus to take charge of the early Christians. But what was it that made him stand out from the other 11 disciples?

Throughout his time following Jesus, Peter displayed a brilliant mind. He would quiz Jesus about the meaning of his parables, demonstrating the hunger for knowledge and confidence that accompanies natural authority. As a leader, Peter displayed an openness and independence of mind that set him apart. When Mary Magdalene reported finding Jesus's tomb empty on the third day after his crucifixion, Peter was the only disciple to believe her – and the only one to run to the tomb to see for himself. A tale from the Bible further illustrates his standing: when tax collectors asked the disciples whether

Jesus paid the temple tax, it was Peter they addressed, having assumed him to be their leader.

As leader of the community of Christians in Jerusalem, Peter would preach inspiring sermons and acted as the disciples' advocate before the religious authorities there. His authority allowed him to lead his disciples during a period of time where they were often faced with persecution and hardship. As head of the Church he travelled widely, preaching in Jesus's name.

In AD44 Peter left his position. After departing Jerusalem, he settled in Rome and headed to the local Christian community there. A decisive and loyal man, to this day Peter is still celebrated as the inspirational figurehead of the church of Rome, the first in the line of 266 popes that run to Pope Francis today.

## CHURCHILL

Inspiring orator who rallied Britain and the world against Hitler's Germany

1874-1965

**W**e will fight on the beaches." "This was their finest hour." "Never was so much owed by so many to so few." These lines have gone down in history

as some of the greatest ever written, spoken by one of the greatest leaders in British history. The man who delivered them: Winston Churchill, Britain's indomitable premier during World War Two who inspired the British public during the conflict's darkest days and led the Allied Forces to victory against Nazi Germany.

The finest leaders are often the greatest orators. This was certainly true in Churchill's case; his unsurpassable rhetoric and public speaking skills were a key component of his success as a figurehead. He possessed the rare ability to inspire the public, even in circumstances that appeared bleak and dispiriting. Churchill's rhetorical powers set him apart from other politicians of the age and rallied the embattled people of Britain to fight back, and fight on, despite the bombardment of their cities during the Blitz (1940-41) and in the threat of a possible Nazi invasion.

Yet for all his reputation as a lofty and inspiring orator, Churchill was also a highly pragmatic leader. His strategic foresight and dogged perseverance were major strengths: he was deeply immersed in the details of military planning and the accompanying technicalities, which meant that his war strategy could react quickly and insightfully to new developments. Churchill understood the importance of alliance in warfare and realised that winning the trust of the US was crucial to British victory. Hitler also recognised that he would be unable to win the war without conquering Britain – and Churchill was fiendishly determined to do everything to prevent this.

The alliance between Britain and the US during World War Two was perhaps Churchill's most significant milestone as wartime prime minister – one vital to victory against the Nazis. For the rest of the war, Churchill worked tirelessly to achieve his aim of defeating Hitler, holding face-to-face conferences, including at Yalta in 1945, to discuss

**LEADERSHIP  
QUALITIES**  
**GIFTED SPEAKER**  
**PRAGMATIC  
PERSEVERING**



**WARTIME ALLIES**  
Churchill pictured with  
Charles de Gaulle in 1944.

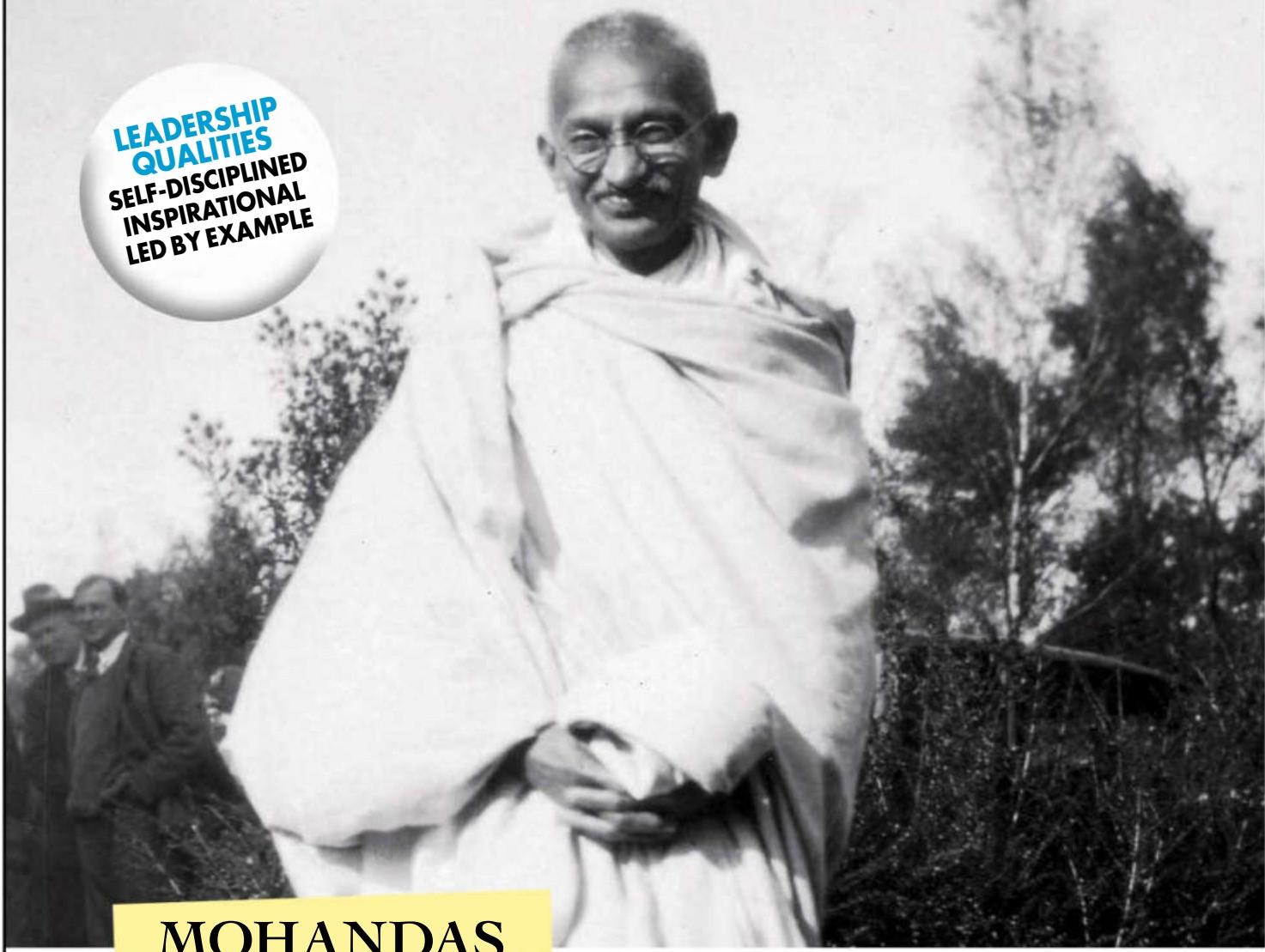
the intricate details of Allied military policy with other world leaders. He also nurtured a personal friendship with President Roosevelt and controlled strong relations with the US throughout the war. Through it all, he maintained a manner of cool assurance, soothing the fears of the British public.

Churchill was, in his own words, the lion that roared just when the British public needed him most. His steely will and refusal to concede even an inch to the enemy have solidified his image in the public consciousness as one of history's most inspiring statesmen. Churchill had no time for defeatism, nor talk of agreeing reasonable terms with Adolf Hitler. This helped to strengthen the resolve of the British people, giving them hope even

when prospects looked grim. It paid off – in 1945, Hitler was finally defeated and Churchill was celebrated at home and abroad as a hero. Without his tenacity, the war may not have been won.

Churchill behaved with enthusiasm, optimism and hard-nosed determination: this was the view he presented to the British public and his allies – not to mention his enemies – abroad. His aim was “victory at all costs – victory in spite of all terror – victory however long and hard the road may be.” He was unwavering in his commitment to this goal and left no stone unturned in his drive to achieve it. For this he is rightly revered as one of the greatest military leaders in history – not just in Great Britain and Europe, but across the globe.

LEADERSHIP  
QUALITIES  
SELF-DISCIPLINED  
INSPIRATIONAL  
LED BY EXAMPLE



## MOHANDAS GANDHI

Pioneering exponent of peaceful protest who set India free

1869-1948

**A**rguably, the ability to persuade is the most essential of leadership qualities – and no one embodies this more than ‘Mahatma’ Gandhi. Like another great leader, Mother Teresa, Gandhi was well known for his self-discipline and self-sacrifice. He practised what he preached at every level. Like the poorest Indians, he wore a basic cotton cloth that barely covered his body and the most rudimentary watch and glasses.

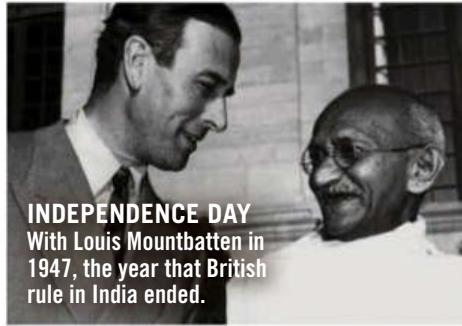
As a student Gandhi was never particularly successful, and he often stressed how ordinary he actually was. Yet he was compelled to constantly improve himself, morally and spiritually. This is what motivated him and led him to the heights he

reached as a nationalist leader and religious exemplar. But true to his humble nature, in his eyes what he achieved was not extraordinary at all. Indeed, he thought it could be attained by everyone: “I have not the shadow of a doubt that any man or woman can achieve what I have, if he or she would make the same effort and cultivate the same hope and faith.”

Gandhi’s character was embodied in his strategy of non-violent resistance, termed ‘satyagraha’ (translation: “holding to the truth”). In the face of injustice, he believed civil disobedience was a citizen’s duty. It should, he wrote, have “no ill will or hatred behind it”. The strength of the satyagraha was its attempt to engage with opponents and win disputes through persuasion, to affect change

without creating an enemy. He was proof that a leader need not rant and rave to get things done.

Gandhi will go down as one of the most transformative figures of the twentieth century. His non-violent revolution in India opened the way to the end of the British Empire in Asia and Africa, and inspired those working against colonialism, racism and violence around the world.

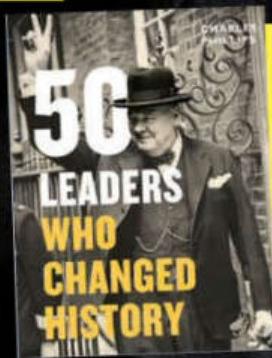


INDEPENDENCE DAY  
With Louis Mountbatten in 1947, the year that British rule in India ended.

# STEVE JOBS

Visionary innovator who spearheaded the personal computer revolution

1955-2011



**BOOK TIP**  
*50 Leaders Who Changed History* by Charles Phillips [Apple Press, \$24.99] will be published on 18th November.

After dropping out of college, Steve Jobs co-founded Apple Inc. from his parents' garage in 1976. His rise to tech stardom is the epitome of the American dream. Innovative, focused and visionary are just some of the accolades commonly ascribed to his legacy. He had a passion for excellence and was obsessed by small details: in a world full of possibility, he was marked by his ability to focus, honing in on the small details that really set Apple's products apart.

He's been described as the modern era's answer to Henry Ford, the man who built the first automobile that ordinary folks could afford, just as Jobs brought computing to the masses. Jobs wasn't interested in doing what had been done before. The iPad, conceived and developed according to Jobs' vision, is a key example of his innovative ideal. Before its release, critics wondered who would buy a smartphone-computer hybrid. But the iPad was an overnight success that stole the hearts of consumers and made Apple a fortune.

Despite this, Jobs was not a leader without flaws. He could be arrogant and uncompromising – in 1985 he was even exiled from Apple for 11 years for ignoring the concerns of the board. Ultimately, however, such imperfections were trumped by his strengths. The Apple boss was a skilled marketer who closely managed the methods used to present the brand to the public. This included weekly meetings with the marketing team and signing off new adverts and commercial campaigns in person – a level of involvement that set Jobs apart from the CEOs of other industry giants, both within the technology field and beyond.

His products were marked by a similar focus on quality and ease of use. He was intimately involved with the design of products and personally tested items in development at Apple's design lab. He imagined himself as an end-user and adhered to the highest standards. This ethos helped to turn Apple into one of the world's most respected brands.

Throughout his career, he demonstrated an innate gift for anticipating – and leading – consumer taste. The first iPhone, unveiled in 2007, was five years ahead of any other mobile phone on the market. And it was a runaway bestseller, cementing Jobs' reputation as a formidable entrepreneur and industry leader. Under his reign, Apple transformed the technology industry and made once-forbidding computing products user-friendly. Thanks to his tireless determination, Apple's late CEO continues to be admired – for the traits that made him such an inspirational leader. **W**



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THE JAMES WEBB SPACE TELESCOPE

# COULD THIS TELESCOPE WITNESS THE BIRTH OF THE UNIVERSE?

It will cost \$8.7 billion and is the size of a Boeing 747: engineers are currently building the most powerful space telescope in the world. The focus of its research? The first galaxies, the universe before stars formed – and the origins of life

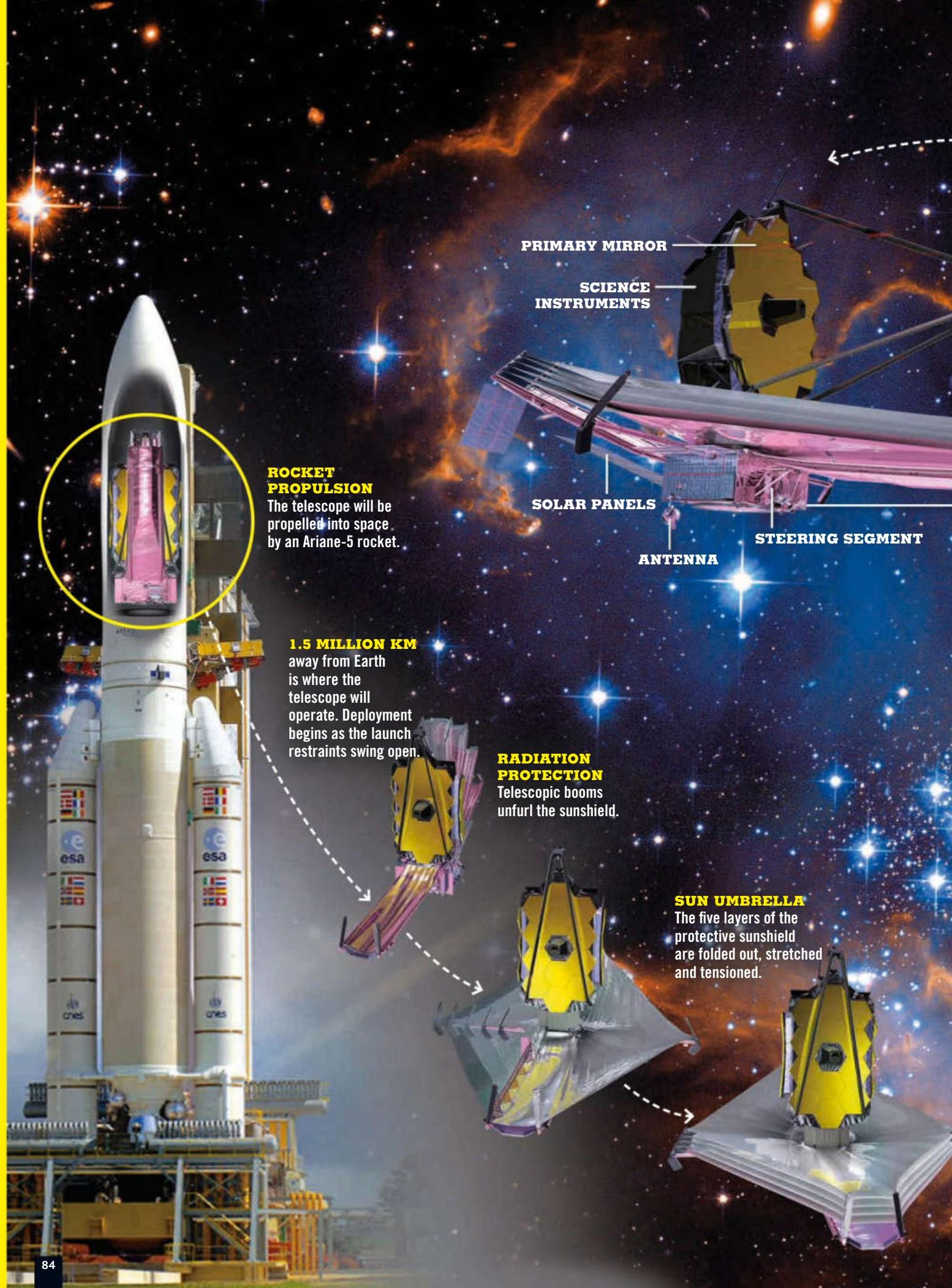


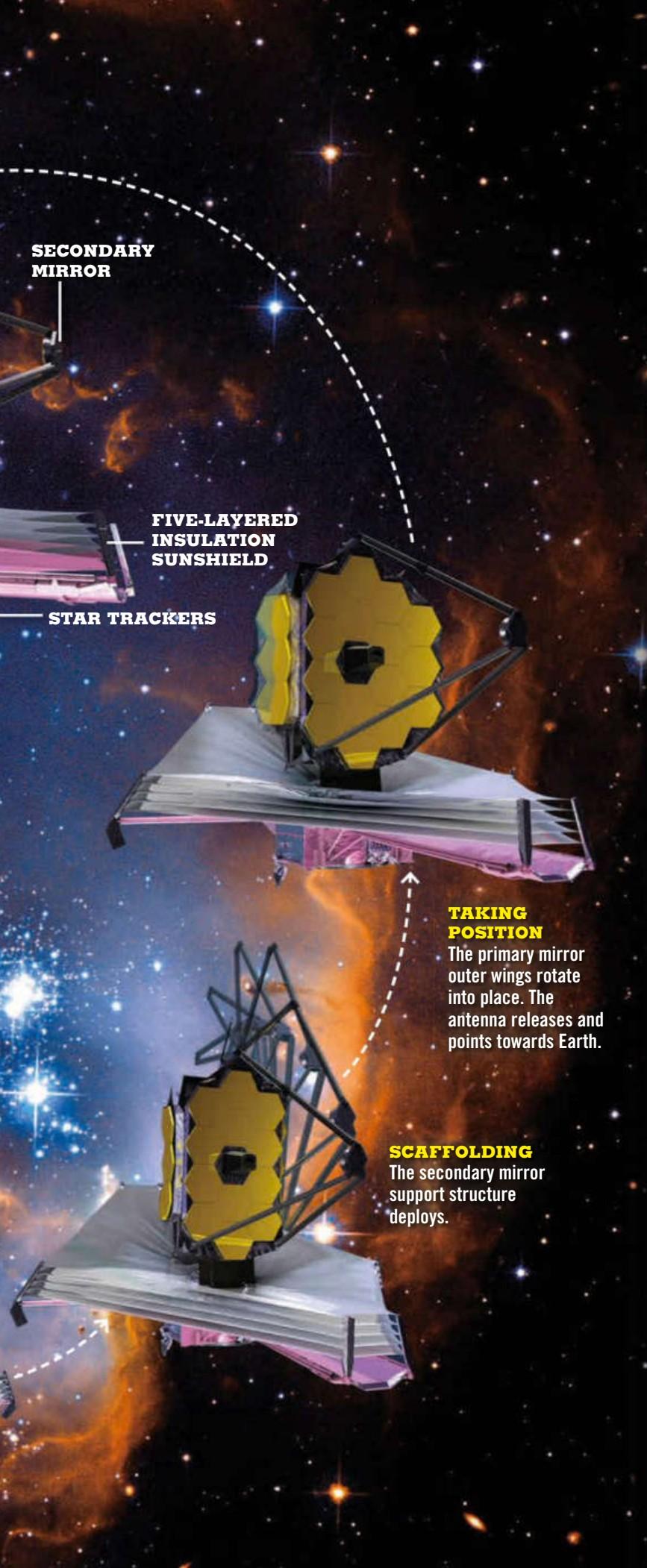
### SPACE DRAMA!

Use the free viewa app and scan this page to watch a cool animation of the JWST's deployment. And more!

### HOW MUCH COLD CAN THIS HUGE MIRROR WITHSTAND?

Engineers cool the new telescope's mirrors down to minus 260 degrees Celsius in the so-called 'Chamber of Horrors' [pictured]. In this space simulator, experts test how the light metal beryllium and the gold coating cope with extreme temperatures.



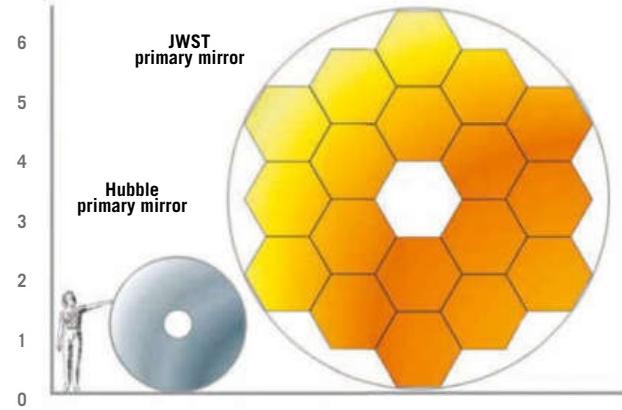


# THE WEBB TELESCOPE: THE REAL TRANSFORMER

A device as huge as the James Webb Space Telescope – it's the size of a tennis court and the height of a four-storey building – has never been transported into space before. To facilitate this, engineers have developed a new approach: the JWST is designed so that it can be folded, and will fit inside an Ariane-5 rocket. After 30 days in outer space, 1.5 million kilometres from Earth, the telescope is ejected from the rocket and will undergo a massive transformation, one of the biggest ever among technological devices [left]. Even some of the telescope's mirror segments can be folded out, too. The protective sunshield consists of five layers of an incredibly strong and heat-resistant material called Kapton, and measures 264 square metres when fully opened. It keeps the telescope cool and protects the crucial infrared sensors from solar radiation. By capturing distant glimmers of ancient light, the astronomers hope to investigate the chemical composition of stars. Beginning in 2018, and running for a minimum of five years, the telescope will begin to unlock the mysteries of the universe. It probably won't last longer than a decade – but even that would be three to five times longer than its predecessors.

## Comparing two space telescopes

Height in metres



# G

igantic gas clouds swirl through the young universe. They collide with one another, forming dense vortexes. More and more gas is pulled in by the suction effect – it is the birth of the first galaxy. “Until recently we could only guess at how it all played out. But soon we’ll be able to see this magical process in precise detail,” says John Mather, project leader of the James Webb Space Telescope (JWST). “And we will see how planetary systems form. Perhaps we will even discover new life forms.” The JWST will grant us a view into the mysteries of the universe.

How will it do so? The European Space Agency explains: “When stars are formed they’re usually nestled inside a dusty cocoon. Using the infrared part of the spectrum, the JWST will be able to penetrate the dusty envelopes around newborn stars and take a closer look at the stars themselves.” The most expensive, and complex, measuring instrument in the world will embark on its mission by 2018 – but first it must pass several tests.

Astronomy’s new ‘eye’ consists of three main components: a 6.5-metre mirror, an infrared sensor and

a highly sensitive camera. “As a result of this technology, the telescope will capture extremely old light that was first emitted billions of years ago and has been travelling through the universe since then,” explains Amber Straughn, deputy project scientist of the JWST. “It is the first light that the universe emitted.” That’s because the earliest point in time covered by the JWST is exactly when space began to radiate light.

Before this point there was an incredibly dense fog composed of shooting electrons, which eventually bound to atomic nuclei as the universe cooled. This set free the light particles trapped in the fog. “If we could get a picture of that moment, when the thick fog was illuminated and the cosmos became transparent, it would be a sensation,” says Carlos Frenk, an astrophysicist at Durham University. “It would show a blinding explosion of light, as trillions of photons escaped.” This first firework holds fascinating information about the origins of the universe as this light formed immediately after the Big Bang.

“We still know nothing about the processes that took place during the formation of the cosmos. Even the tiniest clues could help us,” Frenk explains. From the spectrum of light, researchers could also deduce the chemical composition of the early universe, among other things.

## HOW DO YOU SIMULATE DEEP SPACE?

But in order to be able to catch a glimpse of the universe’s distant past,

the JWST must first be catapulted into space: 1.5 million kilometres from Earth – four times the distance between our blue dot and the moon – where it will unfold. There it will float, held steady by the gravitational pull of the Earth and the sun. The temperature is minus 271 degrees Celsius and there’s zero gravity. These conditions present real challenges for the telescope’s technology. For this reason the engineers

“UNFORESEEN PROBLEMS? THEY’RE TO BE EXPECTED!”

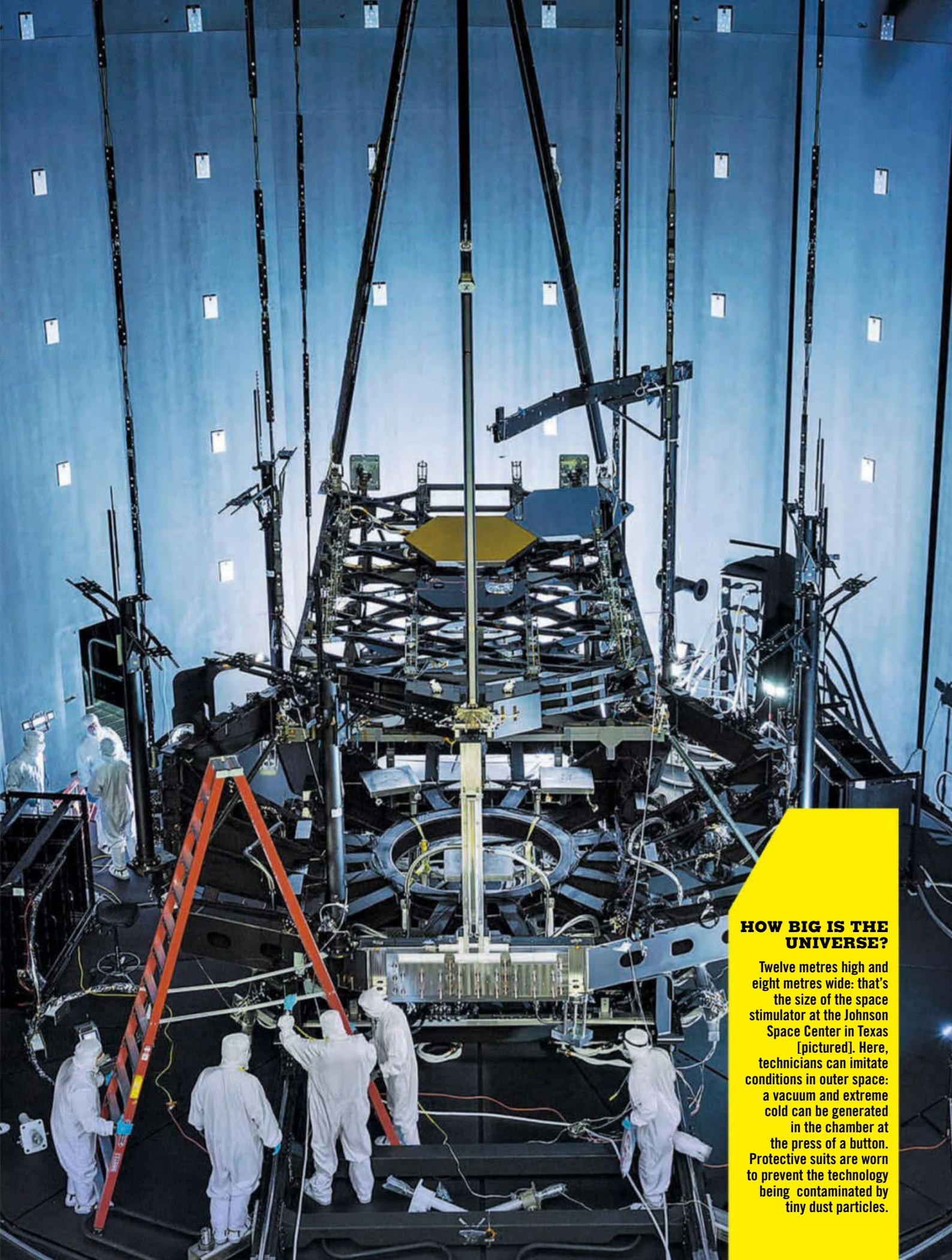


## HOW LIGHT IS A LIGHT METAL?

The mirror in the James Webb Telescope is six times the size of its predecessors, but is much lighter: it weighs just 700kg (the Hubble telescope weighed 800kg) as it is made from beryllium instead of glass. This light metal is first pulverised before being pressed, polished and eventually coated in gold to form the JWST’s primary mirror.

are honing parts of the telescope in the testing facility, nicknamed the ‘Chamber of Horrors’, at the Goddard Space Flight Center in Washington D.C.

Several of the JWST’s instruments have already been subjected to the super-chilled conditions there for 116 days. As a result of the extreme cooling in the vacuum, the deployment mechanism could become stuck and the lubricant may not work properly. The weightless conditions can also draw moisture out of the supporting structure, which then freezes on the camera lens. Another problem: the mirror’s shape can be warped by the chill. To keep this effect to a minimum, the engineers

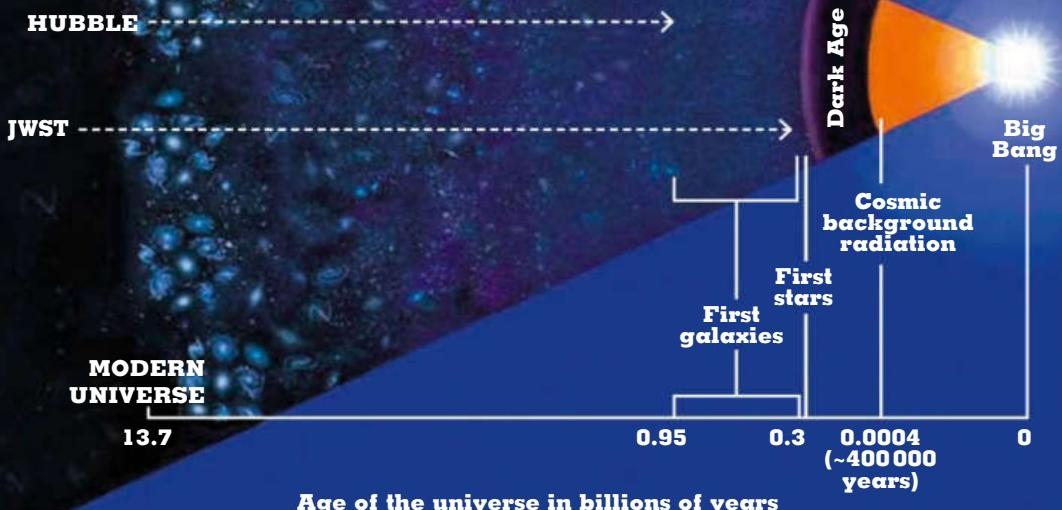


### HOW BIG IS THE UNIVERSE?

Twelve metres high and eight metres wide: that's the size of the space stimulator at the Johnson Space Center in Texas [pictured]. Here, technicians can imitate conditions in outer space: a vacuum and extreme cold can be generated in the chamber at the press of a button. Protective suits are worn to prevent the technology being contaminated by tiny dust particles.

# LOOKING BACK IN TIME

The JWST will become humanity's sharpest eye – astronomers will be able to see through thick clouds of cosmic dust to find newly forming planetary systems. The high-tech device will capture infrared light that has been travelling through space for 13.6 billion years. Astrophysicists will be able to observe how stars formed and hope to unlock the mysteries of the Big Bang.



built the mirror from beryllium, a light but extremely robust metal. Despite its ingenious construction, the mirror will still undergo some contortion – which must be planned for. “We have to build the JWST incorrectly at normal room temperature so that it shrinks to precisely the right shape and dimensions when it’s cold,” says project manager Paul Geithner. And once the mega-telescope heads into outer space for the first time, engineers will have no influence on it: unlike Hubble – currently the biggest space

## HOW SHARP IS THE SHARPEST EYE?

Using its 6.4-metre primary mirror and highly sensitive infrared sensors, the JWST could observe a football pitch 550km away in pin-sharp detail.

telescope – the JWST will be too far away to repair should something go wrong. “It’s better that we test them here, and have something go wrong here, and fix it here,” says Carmine Mattiello, head of the test facility at Goddard. “It doesn’t do anybody any good if it’s just orbiting around and it’s broken or doesn’t want to perform.” But if everything goes to plan, the telescope will revolutionise our view of the universe.

## WHAT DOES THE BIRTH OF A STAR LOOK LIKE?

Could life exist outside of our solar system? How do black holes form? What happens when galaxies collide? In the past researchers have only been able to theorise about the answers to such questions. The JWST will deliver evidence. Its size means it resolves more light than Hubble and perceives ancient infrared light that has

been travelling through space for 13.6 billion years. This facilitates a glimpse into the era when the first stars were formed. While Hubble is famous for its images of dying stars, the images that the JWST hopes to capture will deliver evidence of their birth.

The new telescope will be much more precise than its predecessors. It can identify tiny, distant celestial bodies previously obscured by dust. “Soon we will discover new rocky planets and at the same time be able to say whether life could develop there. That’s because we are able to analyse the gases of a planet using the JWST, which are a good marker of organic matter,” says Amber Straughn. “One of our main aims is the search for new forms of life, but we can also discover traces of oxygen and methane in the far corners of space using the light captured by the JWST. This could enlighten us about the origins of life.” **W**

“We’ll be able to see light that has been travelling in space for 13.6 billion years.”

# SMARTER IN 60 SECONDS...

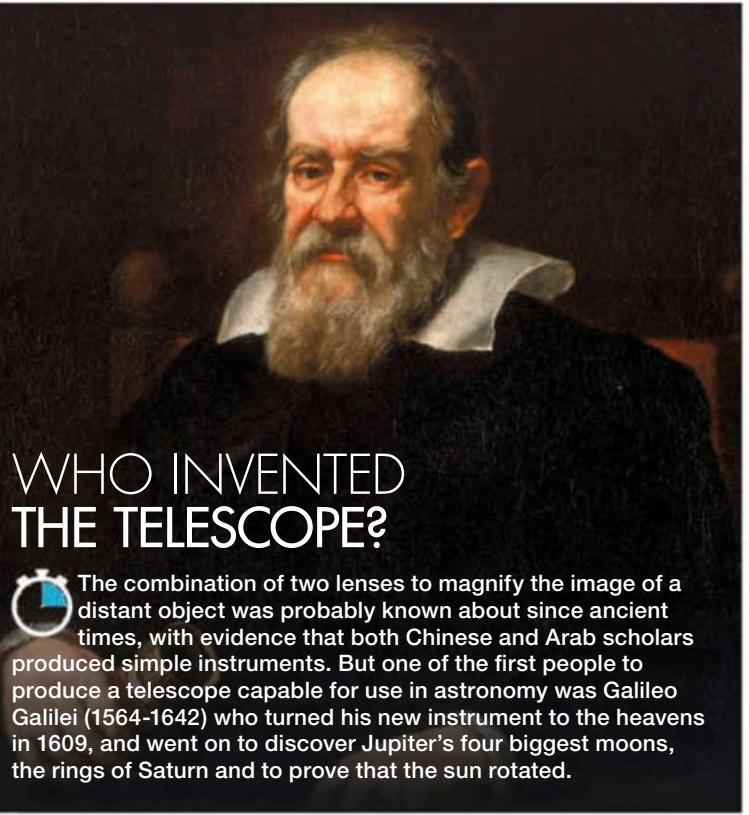
FOUR FASCINATING QUESTIONS ABOUT TELESCOPES

## WHAT'S THE BIGGEST TELESCOPE EVER LOOKED THROUGH?

 The advent of photography and later of digital imaging has meant that astronomers haven't really 'looked' through their scopes since the 1930s. The title of the biggest telescope designed and used as a visual instrument therefore goes to the giant 72-inch reflector telescope built by the third Earl of Ross, William Parsons. His 'Leviathan of Parsonstown' was so big that it had to be held in place between two stone walls and its tube was large enough to host dinner parties inside! The Earl used it to prove that many of the previously observed nebulae were in fact spiral 'star clouds' that would later prove to be distant galaxies.

## WHEN ARE MANY MIRRORS BETTER THAN ONE?

 Telescope building has always been a battle of the biggest, as larger lenses or mirrors allow astronomers to see further into space. But when the optics reach a certain size and weight, gravity can cause distortions that ruin the quality of the image. When reflecting telescopes reached a useable size of around five metres, an alternative way of getting more light was required. In 1979 the Multiple Mirror Telescope saw its first light using an array of six mirrors with a diameter of 1.78 metres to produce a mirror equivalent to 4.5 metres.



## WHO INVENTED THE TELESCOPE?

 The combination of two lenses to magnify the image of a distant object was probably known about since ancient times, with evidence that both Chinese and Arab scholars produced simple instruments. But one of the first people to produce a telescope capable for use in astronomy was Galileo Galilei (1564-1642) who turned his new instrument to the heavens in 1609, and went on to discover Jupiter's four biggest moons, the rings of Saturn and to prove that the sun rotated.

## WHY DID WE SEND A TELESCOPE INTO SPACE?



 Size isn't the final deciding factor in a telescope's ability to decipher the mysteries of the universe. The biggest problem for telescopes based on Earth is our planet's atmosphere. The same thing that keeps us all alive is the bane of astronomers as it limits the ability of any telescope looking through it by unsettling the image and making it impossible to resolve the finest details. Therefore in 1990 the Hubble Space Telescope was launched into Earth orbit where, free from the masking effects of the Earth's atmosphere, it has allowed us to see things like dying stars and distant galaxies in a detail never before imagined.

## OUTDOOR SPECIAL

### 410,000 KILOS

Every cubic metre of water weighs around 1,000kg. Monster waves can weigh up to 410,000kg – that's eight times more than the Titanic.



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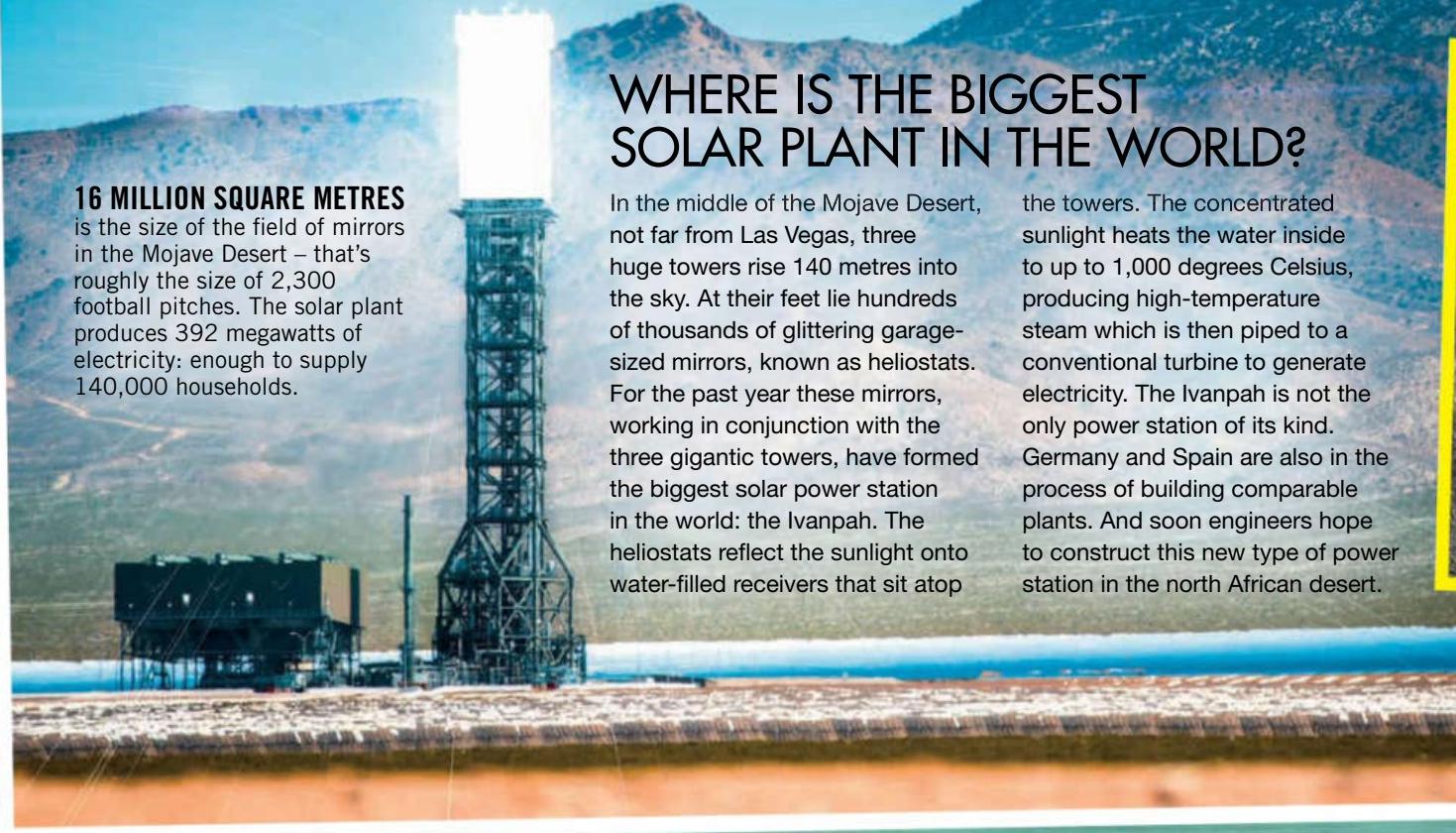
### SUBMERGED

To find the 'perfect wave', surfers must dodge dozens of waves. The trick: diving beneath the walls of water.

# HOW DO I ESCAPE A WAVE?

50 kilometres per hour, weighing several tons and packing the same force as an oncoming lorry – even waves less than a metre high develop incredible power when they break. But can you escape them by paddling away over the white foam? Sadly not. The only way out? Head downwards! Surfers call this technique 'duck-dive'. They breathe in deeply, push their board vertically under water and remain beneath the surface for several seconds until the breaking wave has passed over them. Swimmers should

follow the same rules and dive down as deeply as possible. However, this technique only works when a wave is less than four metres high. If the wave breaking directly in front of a surfer or a swimmer is higher than that, the power of the water would be so strong it would pull everything along with it. In this scenario experts recommend taking a deep breath before the wave hits, protecting your head with your arms and not fighting the suction effect by thrashing around wildly. This will increase your chances of surviving a monster wave unharmed.



**16 MILLION SQUARE METRES**  
is the size of the field of mirrors in the Mojave Desert – that's roughly the size of 2,300 football pitches. The solar plant produces 392 megawatts of electricity: enough to supply 140,000 households.

## WHERE IS THE BIGGEST SOLAR PLANT IN THE WORLD?

In the middle of the Mojave Desert, not far from Las Vegas, three huge towers rise 140 metres into the sky. At their feet lie hundreds of thousands of glittering garage-sized mirrors, known as heliostats. For the past year these mirrors, working in conjunction with the three gigantic towers, have formed the biggest solar power station in the world: the Ivanpah. The heliostats reflect the sunlight onto water-filled receivers that sit atop

the towers. The concentrated sunlight heats the water inside to up to 1,000 degrees Celsius, producing high-temperature steam which is then piped to a conventional turbine to generate electricity. The Ivanpah is not the only power station of its kind. Germany and Spain are also in the process of building comparable plants. And soon engineers hope to construct this new type of power station in the north African desert.

## WHY ARE THERE MORE MURDERS WHEN IT'S HOT?

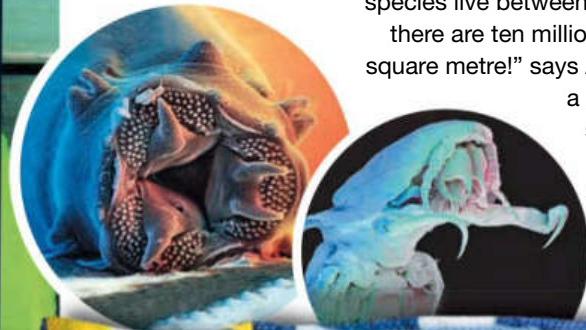
Studies show that the warmer the city, the higher the crime rate. Dennis Rosenbaum, a crime expert at the University of Illinois, found that a city's climate influences its murder rate. "As soon as there's good weather, there's automatically more people out and about on the streets and therefore more offenders and victims around," the scientist explains. Together with psychologist Brad Bushman from the University of Michigan, he concluded that in the USA alone, an increase of 0.4 degrees in the average annual temperature led to almost 10,000 extra murders. "But above 35 degrees Celsius people tend to stay at home, so the increase in murders tails off," says Rosenbaum.



## HOW MUCH LIFE IS HIDING UNDER MY BEACH TOWEL?

Biologist Werner Armonies lifts a handful of sand from the beach on the German island of Sylt. "Hundreds of thousands of tiny creatures are found here," he says. Armonies is an expert on interstitial fauna:

the tiny organisms that live between grains of sand on a beach. A whole variety of life is hurrying around beneath our beach towel: herbivores grazing away happily, predators on the prowl. Over the decades researchers in Sylt have ensured that no beach has been better examined than theirs. "Around 850 different species live between grains of sand here. And there are ten million individual creatures per square metre!" says Armonies. Every beach is a filter, really – because the sea washes up algae and other biomass. Without the animals the beach would quickly turn into a cesspool.



# 4 MILLION

sweat glands are found on the human body. They are located all over – except on the lips.

## HOW MUCH CAN A HUMAN SWEAT?

### 347,000 MIRRORS

surround the three solar towers at the Ivanpah solar power facility in the desert. Each of these so-called heliostats measures seven square metres in size. They are controlled by software which ensures that they are always at an optimum angle to the sun.

### WHERE DOES THE 'ROAR' IN A SEASHELL COME FROM?

Just like any wind instrument, a conch shell contains a column of air which has its own frequency and can serve to amplify the ambient noise around you. Outside of the conch, the natural environment provides a multitude of sounds, which are often so quiet that we can barely perceive them. But the hollow body of the conch captures this noise, which resonates inside the shell. The size and shape of the shell has some effect on the sound you hear – only those tones that are close to the air column's frequency are strengthened. You can even generate the 'roaring' sound in your cupped hand when you're standing on the beach.

People partaking in sport during the summer months will lose around 1.4 litres of liquid per hour through sweat. The sweat-loss record is held by marathon runner Alberto Salazar, who sweated away 3.7 litres an hour during a race in 1984. If you don't balance out the loss of electrolytes and fluids by drinking, you will dehydrate from the inside out. First you'll feel thirsty (after a 2% loss of body fluid). Later, calf cramps and headaches will occur (2-5% loss), caused among other things by the thickening of the blood. In the advanced stage (5-10% loss) you'll suffer from dizziness because of a decrease in blood pressure, alongside cramps, nausea and – finally – cardiac arrest (after 20% of the body's liquids have been lost).



## WHY CAN WE SMELL RAIN IN SUMMER?

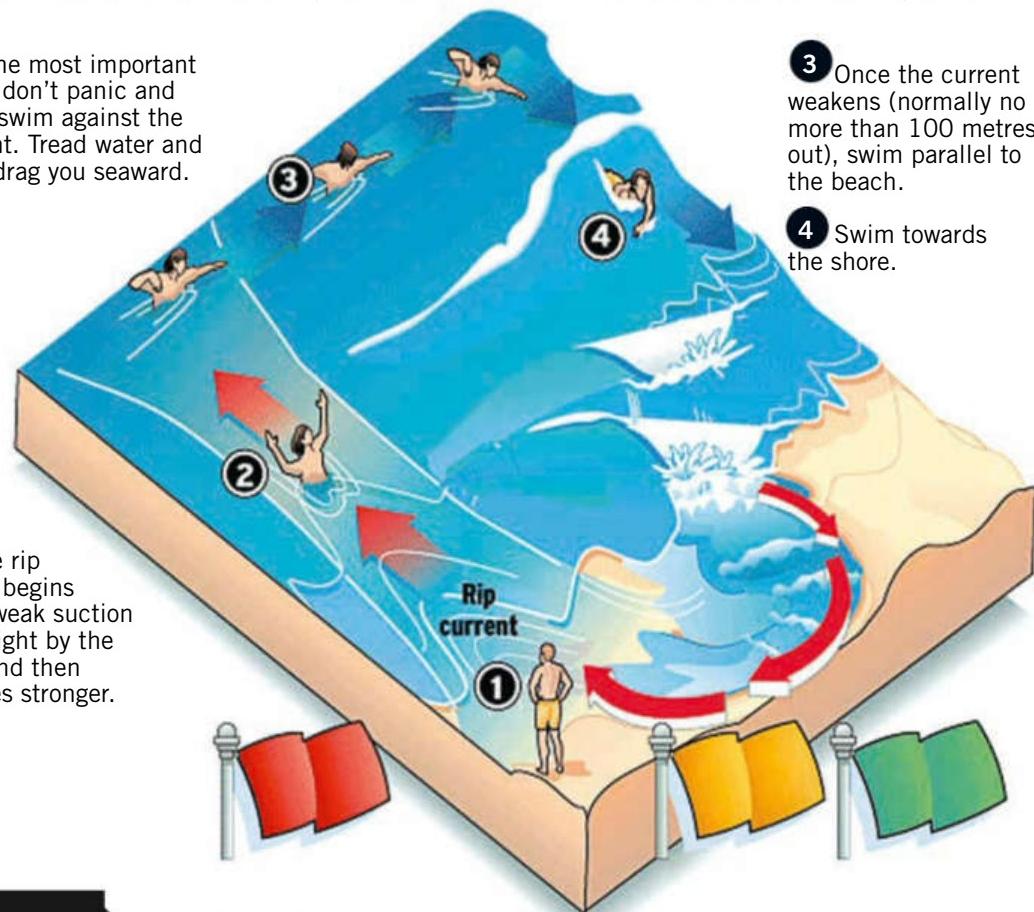
When it rains during the summer months, we can often smell the fresh earthy air once the storm has passed. Why? Rain washes the air clean and pushes dust, pollen and many other harmful particles to the ground – thus we are able to breathe easier and the mucous membranes of the airways are moistened. The musty smell we perceive after a rain shower is

down to microorganisms in the soil – the humidity boosts their metabolic processes and the smell is a by-product of this organic function. When it rains, plants also become more active. Essential oils stream out of their leaves. We can't smell the rain in winter because plants and bacteria are placed on 'metabolic standby' as a result of the lower temperatures.

# WHAT SHOULD YOU DO IF YOU GET CAUGHT IN A RIP CURRENT?

Strong currents – especially those known as rip currents – can be deadly because they can pull a person out to the open sea quickly, miles from shore. They form when waves break in different locations with differing strengths, causing the water to move in a circle (thin red arrows) and then out to sea in a narrow, fast-moving current (wide red arrows). Even the strongest swimmer won't be able to swim against this type of current. Here's what to do instead...

**2** The most important rules: don't panic and don't swim against the current. Tread water and let it drag you seaward.



**1** The rip current begins with a weak suction effect right by the shore and then becomes stronger.

**WHAT DO THE LIFEGUARDS' FLAGS MEAN?**

**RED:** Danger! Only lifeguards allowed in water.

**YELLOW:** Medium risk, swim with caution. Children and people not used to swimming are advised against going in the water.

**GREEN:** No danger, swimming safe for all!

# TOP 10 most toxic ANIMALS



## CLUSTER ANEMONES

**Median Lethal Dose (LD50):** 0.00015 (meaning 0.00015mg/kg is deadly)\*

**Habitat:** Indian Ocean, Indo-Pacific and the Philippines

**Treatment:** no antidote available



## POISON DART FROG

**LD50:** 0.0002

**Habitat:** Central and South America

**Treatment:** no antidote, but the effects can be reversed by using tetrodotoxin



## PUFFER FISH

**LD50:** 0.008

**Habitat:** tropical seas

**Treatment:** artificial respiration, symptoms subside after 24 hours



## SOUTHERN BLUE-RINGED OCTOPUS

**LD50:** 0.02

**Habitat:** Australia, southeast Asia

**Treatment:** same as for puffer fish



## TAIPAN

**LD50:** 0.025

**Habitat:** eastern and northern Australia, Papua New Guinea

**Treatment:** Taipan antivenom



## CONE SNAIL

**LD50:** 0.025

**Habitat:** worldwide in warm waters

**Treatment:** no antidote available



## BOX JELLYFISH

**LD50:** 0.2

**Habitat:** Indo-Pacific, Red Sea

**Treatment:** no specific antivenom, but zinc gluconate may work in some cases



## STONEFISH

**LD50:** 0.2

**Habitat:** Indo-Pacific, Red Sea

**Treatment:** Stonefish antivenom



## DEATHSTALKER SCORPION

**LD50:** 0.33

**Habitat:** North Africa, Turkey, Arabian Peninsula

**Treatment:** antivenom available



## SYDNEY FUNNEL-WEB SPIDER

**LD50:** 0.2-1.5

**Habitat:** eastern Australia

**Treatment:** antivenom available, no deaths have been recorded since its development



## CAN YOU GET SUNBURNT THROUGH A WINDOW?

Windowpanes absorb almost all UVB rays (in the wavelength range 280-315 nanometres), which are predominantly responsible for sunburns and tanning. But UVA rays (in the range 315-400 nanometres) penetrate deeper and can still get through. "If you spend a long time sitting behind untreated glass, the sun's UVA rays can still damage your skin. You'll be exposed to the sun's ageing effects," says dermatologist Anthony Mancini. If you spend a lot of your time driving, then, the more tinted your car windows the better.



## DOES SUMMER EXIST ON MARS?

Mars has seasons because, like Earth, it is tilted on its axis. But its thin atmosphere makes it a chilly planet. During a Martian winter, the temperature can sink as low as minus 125°C. Even on a summer's afternoon, they rarely rise above 10°C. The average temperature on Mars is minus 55°C but despite this it's usually sunny: it doesn't rain and it's only on rare occasions that ice clouds form in the Martian sky. **W**

\* The median lethal dose, or LD50, is a test used in animal experiments and can be used to demonstrate the strength of a toxin. The figures show the amount of toxin needed per kilo of body weight to kill half of all those bitten or stung. The lower the LD50 value, the stronger the toxin.



#### CONSTANT HUNGER

Nothing escapes this harvest mouse. As soon as the rodent has munched through its favourite varieties of corn, attention turns to the main course – butterflies, insects and a few small eggs, please.



# KING OF THE CORNFIELD

Weighing just a few grams, and small enough to fit on a tablespoon, the harvest mouse doesn't let its size get it down. It rules its territories with an iron fist, and catches prey using some astonishing stunts. Never underestimate this tiny rodent

**A** typical summer's day in a cornfield somewhere in rural England. Heavy ears of corn bend close to the ground as the rhythmic chirping of crickets delivers the soundtrack to the shimmering heat. Under the glaring sun, a lone butterfly staggers – rather than flutters – towards a poppy flower. The insect doesn't register the seven grams of furry determination darting out from behind a blade of grass. Two metres up, the attack begins: like a cannonball, the harvest mouse (genus name: *Micromys minutus*) shoots at the butterfly, catching it mid-flight before vanishing between the corn rows at lightning speed. The process lasts just two seconds and satisfies the harvest mouse's hunger pangs. For now...

A cornfield offers all sorts of predators ideal cover to carry out stealth attacks, but no animal understands how to use the vegetation for its own means as well as the 75mm-long

harvest mouse. Thanks to its light weight and specialised paws, these tiny field-dwellers can dangle effortlessly from blades of grass and grain stalks. Their long tails act as both safety rope and anchor. And their hind legs contain some impressive jumping power: harvest mice can catapult themselves 30 centimetres into the air from an ear of corn.

In fact, these mini mice are some of the most successful rodents on the planet: they've conquered vast areas, and can be found all the way from western Europe to Japan. Every rodent inhabits a fixed territory of around 400 square metres – no competitors allowed. It's best that way, because every three hours the little kings' stomachs start to rumble – not just for the seeds and butterflies that feature on its menu, but also for the eggs of small birds. If food is scarce, the rodents will even eat their own compatriots. One very good reason why the little harvest mouse should never be scoffed at. **W**

# LETTERS

\*Letters may be edited for publication

Welcome to *World Of Knowledge*'s new Letters page, where you can share your thoughts on anything you see in the magazine. Write to us at *World Of Knowledge*, GPO Box 4088, NSW, 2001 or email us at [worldofknowledge@bauer-media.com.au](mailto:worldofknowledge@bauer-media.com.au)



## Sweet dreams

**TOSCA TANNENBERG, BY EMAIL**

I enjoyed last issue's article about the body ('100 Facts You Should Know About Your Body'). In the article you explained when a foetus has its first heartbeat. I've got a question that I haven't seen discussed anywhere before – when does an embryo begin to have defined sleeping and waking phases? And do babies in the womb dream?

> A baby develops sleeping patterns between the 28th and 36th weeks of pregnancy. However, even before then a foetus experiences active and calm phases that can be interpreted as sleep. As early as the 8th to 12th week of pregnancy, unborn babies can move in a variety of ways and have bursts of activity alternated with periods of rest. It is during the last three months of pregnancy that the foetus's circadian rhythms emerge. These rhythms, based on a 24-hour cycle, are what make us feel alert during daylight and sleepy at night. At 32 weeks, a baby in the womb behaves almost exactly as a newborn, spending up to 90% of its time in a sleeping state. Some of these hours are spent in deep sleep, others in REM sleep – the sleep of dreams. Scans of foetal brain waves show similarities to adult brain scans recorded during sleep, suggesting that babies in utero can dream – and indeed, may spend a large proportion of their time doing so. During REM sleep, the foetus's eyes flicker just as an adult's do when they dream.

## No pain, no gain

**STEPHEN MADELEY, BY E-MAIL**

I have a question about the article '100 Facts You Should Know About Your Body'. You mentioned the different levels of pain (1-10) humans can endure. In this context, I wondered what the pain level during childbirth would be.

> Pain during childbirth is one of the most severe forms of pain a human can endure, even though the brain is hardwired to try to counteract the pain from the moment of the first contraction and releases endogenous (body-made) opioids. Humans are virtually unique among mammals in experiencing severe pain during childbirth.

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